Textbook Of

Inductive Logic

N. Durzie

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Prescribed by the Council of Higher Secondary Education, Orissa
as a Text Book for +2 Classes

Text Book of
INDUCTIVE LOGIC

VOLUME – II

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PREFACE TO THE EIGHTH EDITION

It is gratifying to note that the books,both Vol. I and Vol. II, have proved themselves useful to the students of the +2 classes and the need for a new edition is felt so soon.

The aim of these books has all along been not only to provide adequate materials on all the topics prescribed in the syllabus, but also to deal with matters necessary for a comprehensive knowledge on the fundamental elements and to acquaint the students with concepts helpful to the advanced study of the subject.

For the convenience of the readers, every discussion, as far as practicable, has been made self-sufficient. So the beginners need have no fear of having a mutilated or distorted knowledge of things, even if they omit the study of some portions or some chapters or even whole chapters as per requirements of the syllabus.

Readers desirous of acquiring knowledge of the advanced works on modern logic, however cannot afford to ignore any topic included in these. books.

Sri Gundicha, 1986 N. Durzie

PREFACE TO THE FIFTH EDITION

While revising the books for this edition, I had the occasion to look through the syllabus prescribed by the Board of Higher Secondary Education for the +2 course. I find that the books satisfacrtorily suit the requirements of the syllabus and no addition or alternation is called for.

Let me hope that the books will be equally well useful to the students preparing the +2 course as they have been to those of the Intermediate class.

N. Durzie

PREFACE TO THE FIRST EDITION

The syllabi of the universities of orissa in logic have been modified and modernised in order to acquaint the students with the views of the modern logicians on the topics dealt in traditional logic. It is necessary, therefore, that the students be supplied with a new Text-book presenting the modern views along with the traditional views on the topics prescribed in the syllabi. This book is the outcome of an attempt to fulfil this need.

Volume I of the 'Text-book of Intermediate Logic' deals with Deduction and Volume II with Induction. The first volume is meant for the First Year Intermediate and the Pre-University students while the second volume is meant for the Second Year Intermediate and the First Year Degree students.

The primary purpose of writing this book is to assist the students of the universities of Orissa in understanding the subject matter of their course in logic and in acquiring ability to answer all types of questions set in these universities. But it is expected that it will also benefit the students of other universities, who follow a similar course.

All attempts have been made to present facts exhaustively in simple language and a number of model questions both of objective and essay type have been given in the exercises, at the end of the chapters. A set of questions of all the three universities have been given at the end of the book. I shall feel gratified if the book is found useful by those for whom it is written.

I wish to express my gratitude to Prof. S. R. Mukherjee for his going through the manuscript and giving me valuable suggestions and to Prof. R. Sarangi for going through the proofs.

Sripanchami *AUTHOR*
1974

SYLLABUS – 2001

Logic – Paper – I

First Year +2 Course or class – XI

1. Nature and Scope of Logic : Truth and validity, the principles of logic. The laws of Identity, Contradiction, excluded middle.
2. Words and Terms : Denotation and Connotation (Extension and Intention) Classification of Terms, predicables, Genus, Species, Differantia, Proprium and Accidents.
3. Difinition : Connotative and obstensive, Rules and fallacies of Definition.
4. Division : Rules and fallacies of Devision.
5. Proposition : Nature of proposition, Sentence and Proposition, Traditional Analysis of proposition - Quality, Quantity and Relation. Hypothetical, Disjunctive and Modern Analysis of Propositions, Simple, General and Compound Proposition, Relation between proposition - Seven fold relation.
6. Inference : Immediate and Mediate.

   Immediate inference : Conversion and Obversion.

   Mediate Inference Syllogism : Its different forms-Categorical syllogism, Its nature and structure, Figure and Mood-Syllogitic Rules (General and special), Determination of valid moods. Aristotles Dictum, Reduction-Direct and Indirect, Mixed Syllogism- Hypothetical-Categorical, Disjunctive-Categorical

   Alternative- Categorical, Dilemma.
7. Nature of Symbolic Logic : Variables, Constants. Truth Functions and Truth Tables-Conjunction, Alternative, Implication and Equivalence.

PAPER-II

2nd Year of +2 Course or class – XII

1. Nature, Problem and procedure of Induction.
2. Induction Proper and Induction Improperly so-called.
3. Grounds of Induction-Formal Ground-Laws of uniformity of Nature and Causation-Scientific and popular view of causation-cause and condition-Quantitative and Qualitative view of causation-Doctrine of Plurality of causes. Conjuction of causes and Intermixture of Effects.
4. Hypothesis-Conditions of Legitimate Hypothesis-Proofs of Hypothesis.
5. Material Ground-Observation and Experiment.
6. The Experimental Methods-Method of Agreement, Method of Difference, Joint Method of Agreement and Difference, Method of Concomitant Variation and Method of Residues. Concept of Vyapti.
7. Fallacies-Deductive-Logical and Non-logical.
8. Fallacies-Inductive.

CONTENTS

1

Nature, Problem & Procedure of Induction

What is Inductive Logic ?

LOGIC as we know is a formal science which discovers the formal principles of proof and the valid forms of reasoning. It also discusses the subsidiary topics related to reasoning. In a valid form of reasoning, if we take true premises obtained by observed facts as its premises, the conclusion necessarily becomes true, whether it be supported by other available evidence or not. The truth of the premises is sufficient evidence to justify the conclusion, and the conclusion is taken as true. So though the primary concern of Pure Logic is these forms of reasoning, Applied Logic tends to become the "art of thinking" or the "art of disputation" in order to arrive at truth by reasoning. So Logic is said to be a science which provides us with the means by which knowledge can be gained inferentially or indirectly.

Deductive Logic deals with implication and the reasoning here is conclusive. The conclusion asserts nothing more than what is implied in the premises and the conclusion is as certain as the premise or premises. Inductive Logic, on the other hand, deals with generalisation and the reasoning here is not as conclusive as that of Deductive Logic. The conclusion asserts more than what is implied in the premises, and so even though all the premises be true, the possibility of the conclusion being false is not completely ruled out.

Generalisations, however, are of very great importance in our everyday life and in the fields of the sciences. All our plans for the

future depend on generalisation and there should be some logical methods justifying generalisation. It is Inductive Logic which examines the forms of reasoning employed in generalisation and assesses their value.

It may be noted that neither Deductive nor Inductive Logic purely as a science is directly concerned with truth. Their primary concern is the mode of reasoning. But as arts these modes of reasoning are applied in concrete cases and true knowledge of matters of fact may be obtained inferentially.

Further, Deductive Logic, since it examines the implication only, can afford to remain purely formal. But Inductive Logic, since it examines the modes of generalisation, takes into consideration concrete cases and thus the conclusions are aimed to be both formally sound and materially true. Observation and Experiment which give us direct knowledge of facts are, therefore, enlisted as subsidiary topics in Inductive Logic.

The term 'induction' has come down to us from a Greek word used by Aristotle through its Latin equivalent *'Epagoge'*. It usually means gaining knowledge of general principles from the knowledge of particular instances. Now, empirical sciences like Physics, Chemistry, Biology, Geology etc, are engaged in discovering and establishing general principles or laws of nature by observation of and experiment on particular facts of experience. So these sciences are based on Induction. Bennet and Baylis have described Induction as "empirical probability argument". This description is given in order to indicate that empirical sciences depend on Induction, and the conclusion of Induction is probable. It should be noted, however,that the aim of sciences is not simply gaining knowledge of general principles, but also systematisation of the knowledge gained. For this deduction is also necessary.

Necessity of Induction

Logic is required to gain indirect knowledge. We get indirect knowledge by inference. An inference consists of premises and

conclusion. The conclusion is derived from the premises. In a valid inference the premises imply the conclusion, i.e., if the premises are taken to be true, the conclusion must be taken to be true.

Let us take some instances of valid inference.

1.	A	—	All men are mortal.
	A	—	All students are men.
∴	A	—	All students are mortal
2.	A	—	All men are immortal.
	A	—	Ram is a man.
∴	A	—	Ram is immortal.

Both the above syllogisms are logically valid. Both are in Barbara. But we know that the conclusion of (1) is true as a matter of fact and the conclusion of (2) is not true as a matter of fact. (1) is both formally and materially true. (2) is formally true but materially false.

To be useful in life our knowledge should be both formally and materially true. How can we have such knowledge ?

A conclusion is formally true, if the rules of inference are correctly applied, i.e., if the inference is valid, e.g., (1) and (2). It is materially true, if the premises are materially true and the inference is valid, e.g., (1).

Now, how do we know whether the premises are materially true or not ?

The premises may be :

(i) Singular Propositions, e.g., Ram is a student of +2 class.

(ii) Particular propositions, e.g., Some boys of this class are tall.

(iii) Apparently General Propositions, e.g., All boys of this class are more than 5 ft. 3 inches in height.

(iv) Really General Propositions, e.g., All men are mortal.

Material truth of propositions like (i), (ii) and (iii) can be known by experience. We examine the boys of +2 class. If a boy bears the name Ram, (i) is true. If no such boy be there, (i) is false.

(ii) will be true if at least one of the boys of the class is tall. It will be false, if not a single boy is tall. Similarly the truth or falsity of (iii) can be established by experience, because the class must have a limited number of boys and we can examine each one of them.

It is not possible to establish the truth of propositions like (iv) by experience. They are propositions about unlimited totality. 'All men' here means all human beings of past, present and future. It is impossible to examine all of them. So the truth of such unrestricted general propositions cannot be established by experience, though they can be falsified by experience, if a contrary instance is discovered. General propositions of this type may be :

(i) Analytical or verbal, e.g., All men are rational animals.

(ii) Synthetical or real, e.g., All men are mortal.

We can know the truth of verbal propositions by analysing the meaning of the subject term. The predicates of such propositions are the connotation or part of the connotation of the subject terms. But the predicates of synthetical or real propositions are new terms not contained in the connotation of their subjects.

Real General propositions may be :

(i) Axioms, e.g., 'Matter is composed of distinct particles called molecule' is an axiom of physics.

(ii) Deductions, e.g., 'All students are mortal' is deduced from 'All men are mortal'.

(iii) Neither axioms nor deductions, e.g., All living things are mortal.

Axioms are self-evident propositions, which need no proof. Deductions are deduced from more general propositions. But all real general propositions, which are neither axioms nor deductions from higher propositions, must be established somehow. It is Induction which establishes such propositions.

In every valid syllogism, there must be a general proposition. If it be a real general proposition, which is neither an axiom nor a deduction, it can be established to be true only by Induction. So

Induction is an essential part of gaining knowledge by logical reasoning.

Meaning and Nature of Induction

Aristotle seems to have named that process 'induction', by which we see that a general principle is involved in a particular case. For example, we see a red patch and a pink patch and come to the conclusion that *any* red patch is darker than *any* pink patch. Johnson names this process 'Intutitive Induction'.

Aristotle called that process also 'Induction', which examines all the members of a limited class or all the species of a genus, and finding a common property passes on to a generalisation about the concerned class as having that property. The process of reaching the conclusions, 'All continents have living beings' and 'All bileless animals (man, horse, mule) are long-lived' illustrates this type of induction. Johnson has named this process 'Summary Induction'.

Scholastic Logicians of the Medieval period used the term 'induction' for that process, which arrives at a generalisation by examining all the instances or some of the instances covered by it. When all the instances were observed, it was named 'Perfect Induction', and when only some of the instances were observed, it was named 'Imperfect Induction'. The conclusion : 'All continents have living beings' can be established by Perfect Induction, since we can examine all the continents. The conclusion : 'All lions are tawny' can be reached by Imperfect Induction, since we cannot observe all lions of past, present and future. These processes are generally named 'Enumerative Induction'.

According to Bacon, induction is concerned with the discovery of 'form' or essence of natural things. His inductive process had three steps : (i) Collection of instances, (ii) Sorting of instances under the table of presence, table of absence and the table of degrees and (iii) Exclusion or rejection of what is not the form. Bacon laid great emphasis on the third step, which is generally called 'Elimination by varying the circumstances'.

Mill's conception of induction and inductive method is to a great extent similar to that of Bacon. The best form of Induction, according to him, is Scientific Induction, which is based on a causal connection. He formulates five experimental methods with the purpose to discover and prove causal connection. These methods are similar to the Tables of Bacon.

Mill, however, takes other weaker kinds of generalisation also to be induction. According to him, 'Induction is the process by which we conclude that what is true of certain individuals of a class is true of the whole class, or that what is true at certain times will be true in similar circumstances at all times.

Modern Logicians consider the view of Bacon and Mill on induction to be too restricted. The process of generalisation from an observation of a limited number of instances is called 'Primary Induction'. Besides this, another form of induction is recognised by Nicod and Eaton, which is called Secondary Induction'.

The characteristics of Primary Induction may be indicated thus:

(i) It is based on observation of facts. We observe a number of lions and finding them all to be tawny, come to the conclusion that all the lions (observed or unobserved) are tawny. Thus it is concerned with factual or material truth.

(ii) It establishes a general real proposition. A general proposition is a statement about an unlimited totality, an unrestricted class. The material truth of a statement regarding one or some individuals can be known by direct experience. Knowledge about a limited totality (e.g., all observed lions) can also be gained by direct experience. Truth of a verbal or analytical proposition (e. g., all lions are beasts) can be realised by an analysis of the meaning of the subject term. But the truth of a general real proposition, i.e., a synthetic proposition of unlimited totality (e. g., all lions of past, present and future are tawny) cannot be established either by direct experience or by analysis.

Primary Induction aims to establish the material truth of such propositions.

(iii) It is an inference. We observe some cases and pass on to all similar cases. So there is a passage from 'some' to 'all'. Knowledge of facts other than what is known by direct experience is involved here. This process of passing from 'some' to 'all' is said to be the 'inductive leap'. This leap from the 'observed' to the 'unobserved', from the 'known' to the 'unknown' is admitted to be a leap in the dark, a risk, but it has to be taken, otherwise induction will be not at all an inference.

(iv) Its conclusion is probable, not certain. The 'inductive leap' renders the conclusion of induction probable. The extent of observation may be very wide. Instances disproving the conclusion may be totally lacking so far. But still we cannot say that the future lions are bound to be tawny. We may believe in uniformity of nature. We may claim that our generalisation is based on a causal connection. But whatever empirical justification there may be for the inductive leap, there is no logical justification for it. Inference from 'Some S is P' to 'All S is P' is clearly invalid. So inductive generalisations may be highly probable, may be almost certain or practically certain, but cannot be absolutely or logically certain.

(v) Primary induction is based upon resemblance. The observed instances are members of a class. So they resemble one another in many respects. The generalisation comprises both the observed and the unobserved instances, but the unobserved instances are also the members of the same class and must resemble the observed ones, otherwise they cannot be reckoned as the members of the same class. It is because of this similarity that the inference from 'some' to 'all' becomes possible. This characteristic of induction is clear from the definition of induction given

> by Mill : "Induction, then, is that operation of the mind, by which we infer that what we know to be true in a particular case or cases, will be true in all cases, which resemble the former in certain assignable respects".

Secondary Induction is the process of establishing theories or non-instantial hypotheses by indirect verification.

Primary Induction is concerned with generalisations made directly from facts of experience. We observe some lions and conclude that "All lions are tawny". We conduct some experiments on lead and come to the conclusion that 'Lead always melts at a temperature of 327° Centigrade'. In some cases, the generalisations are preceded by formation of hypotheses and testing of them by direct or indirect verification. Hypothesis is a tentative supposition, which is put forward for explaining facts. In the case of malarial fever, the hypothesis that it is caused by bite of anopheles was framed and was verified to be correct. This led to the generalisation that, 'All malarial fevers are caused by bite of anopheles'.

Secondary Induction is necessary for systematisation of the generalisations made in a science. Newton's law of Universal Gravitation is established by Secondary Induction. This law may be stated thus : "Every particle of matter attracts every other particle with a force directly proportional to the product of the masses and inversely proportional to the square of the distance between the centres of the masses". Such a general principle is called a non-instantial or transcendent hypothesis, because we do not get in our experience instances exemplifying this hypothesis, to verify directly. It transcends or goes beyond the facts of ordinary experience and formulates a hypothesis which can be verified only indirectly, i.e., through the verification of the consequences deduced from it. The justification for the formulation of such a hypothesis and holding it to be true lies not in finding instances exemplifying it but in its capacity to explain and systematise the generalisations made from facts of experience by Primary Inductions.

From concrete facts of experience generalisations are made by Primary Induction, which can be directly verified. Higher and more abstract generalisations are then made which interlace and explain the lower generalisations and ultimately a transcendent hypothesis is formulated which explains and systematises all or most of the lower level generalisations covering a wide field of knowledge. The process of establishing such transcendent hypotheses is called **Secondary Induction.**

The characteristics of Secondary Induction may be indicated thus :

(i) It establishes a transcendent or non-instantial hypothesis, which systematises the knowledge gained in a science or sciences. The law of universal gravitation systematises the laws of falling bodies on Earth, the laws of tides and the laws of planetary motions.

(ii) It applies the hypothetico-deductive method in order to establish its conclusion. This method consists in framing a hypothesis and deducing its consequences that can be verified. The framing of a hypothesis requires thorough knowledge of the subject-matter, deep insight and constructive imagination. Many wrong hypotheses may precede the right one. The ability to frame a non-instantial hypothesis which stands the test of time is acquired by only great geniuses. After the framing of such a hypothesis, deductions are made from it to see whether the already well-established laws are deducible from it or not. That hypothesis is ultimately accepted to be correct, which satisfactorily explains all the generalisations or laws that come within its scope. The law of universal gravitation could explain a large number of laws concerned with different kinds of motion. But the theory of relativity of Einstein supersedes it. It explains more satisfactorily what could be explained by the law of universal gravitation and

also explains what could not be explained by this law. So to-day, the theory of relativity is accepted to be correct, and recognised to be a higher transcendent hypothesis than the law of universal gravitation.

(iii) Its conclusion is tested by indirect verification.

The conclusion of primary Induction can be tested by the process of either direct verification or indirect verification or both. In the case of some generalisations, e.g., All lions are tawny, direct verification is possible, since we can find instances of lions being tawny. In the case of hypotheses about very very minute germs causing diseases, indirect verification is sought till the germs are detected by powerful microscopes. In the case of a non-instantial hypothesis, such instances are not available. So it is only indirectly verified through the verification of the laws that are deduced from it. From the non-instantial hypothesis, by the process of deduction lower and still lower laws are derived and the lowest level laws are verified by a direct appeal to facts. Every direct evidence in support of the lowest level laws is an indirect evidence in support of the non-instantial hypothesis from which they are deducible. This is the only available verification-procedure for Secondary Induction which aims at establishing non-instantial hypotheses.

(iv) Its conclusion is probable, not certain.

No induction, whether primary or secondary can give a logically certain conclusion. It is so, because it has to depend ultimately on facts for its verification whether it be direct or indirect. As long as facts of the universe remain the same, the well-established laws of science are true and remain unmodified. The discovery of a single contrary instance necessitates modification, if not rejection, of all the laws concerned with it. Since there is no

end to scientific discovery of new facts, no law or theory about empirical facts can be absolutely certain.

Now, we are in a position to give a definition of induction that would cover both primary and secondary induction. Mill's conception of the aim of science is faulty and his definition of induction suits only the Primary Induction. In modern times, the aim of science is considered to be not only the establishment of laws of nature, but also the ordering and systematisation of the laws. Inductive Logic is concerned with the methodology of the empirical sciences. So it should be defined as 'the process of establishing general real propositions from facts of experience and of establishing transcendental hypotheses to systematise the generalisations'.

Problem of Induction

Induction establishes the material truth of a general real proposition. For this purpose it begins with the examination of some particular instances. From experience we know that Ram, Sita, Akbar etc. are mortal. But howsoever wide our experience may be, is it possible to examine all the instances covered by 'All men' ? It is obviously impossible to examine all the instances of 'all men', because 'all men' includes human beings of past, present and future. So the question arises—how is it that from the knowledge of a limited number of cases, we pass on to the knowledge of all cases ? How do we pass from the known to the unknown, from the observed to the unobserved ? This is the problem of Induction.

Mill states the problem by raising a question of this type—Why is it that in some cases one or two instances are sufficient for a generalisation, but in some other cases thousands of instances are not sufficient for a generalisation ?

The problem of arriving at a general conclusion from an experience of a limited number of cases has been solved differently by different logicians.

Aristotle tried to solve the problem by an Inductive syllogism.

e.g. The cow, the buffalo, the sheep etc. ruminate.

The cow, the buffalo, the sheep etc. are all horned animals.

∴ All horned animals ruminate.

This solution is considered unsatisfactory, because 'etc' makes the premise vague. Aristotle seems to imply that all the species of the genus'horned animals' should be examined and exhausted. But obviously we cannot examine all the members of a species of animals. So only some members of all the species of horned animals have been examined in the above inductive syllogism. But its conclusion is about all the members of all the species of horned animals. So the problem as to how to pass from 'some' to 'all ' is not solved.

Hume says that the problem of Induction cannot be solved and we are not justified in passing from the present to the future.

Mill and Bain say that the solution depends on our reliance on the principle of Universal Causation and the Principle of Uniformity of Nature.

Principle of UniversalCausation states that every event must have a cause. Principle of Uniformity of Nature states that nature behaves in the same manner under similar circumstances. So the same cause produces the same effect always.

From experience we know that some men like Ram, Sita, Akbar, Alice etc. die. Relying on the law of causation we try to find out the cause of their death. By scientific methods we come to know that 'having life' is the cause of their death.

Now we may consider whether 'having life' is an essential quality of man or not. If it is an essential quality it must be found in every man. Without this quality, nothing can be considered as man.

We find that 'having life' is an essential quality of man. So wherever there be a man in past, present and future, he must have life. And if nature is uniform in every case, this quality will lead to

the same effect, i. e., death. Thus we come to the conclusion that 'All men are mortal'.

So, Mill may answer to the question as stated above thus :

In those cases, where the causal relation is established with an essential quality, one or two instances are sufficient for the generalisation, e. g., All Indians are mortal.

In those cases, where the causal relation is established with an accidental quality, thousands of instances are not sufficient for a generalisation,e.g., All Indians are superstitious.

The principles advanced by Mill and Bain for the solution of the inductive problem have not received universal acceptance, and alternative principles have been advanced by other logicians. Further, the certainty of these principles has been challenged, since they are neither axiomatic nor provable. They are at best beliefs which are not unreasonable. So they render the conclusion of Induction probable or reasonable, but not certain as Mill supposed the conclusion of Scientific Induction to be.

Procedure of Induction

Inductive procedure is the process of reaching a general conclusion from an examination of particular instances. It involves several steps.

I. The first step consists of observation, definition, analysis and elimination.

Suppose, we want to establish a general proposition by finding out the cause of malarial fever. We should begin by a preliminary observation of several cases of this fever and note its characteristics. This will enable us to give a definition of malarial fever and our observation can be confined to cases of only this fever. Malarial fever should not be confused with fevers like influenza or typhoid. We should observe many more cases of Malaria and note the preceding, accompanying and succeeding circumstances. We should vary the circumstances and differentiate the constant factors from

the changing ones. A careful analysis of the different factors will enable us to distinguish the common and essential factors from the changing and accidental ones. Then the accidental factors may be eliminated, because they cannot be the cause of the fever. The essential factors are to be noted, because some of them must have been the cause of the fever. Let us suppose that by such a procedure we note that (a) unhealthy habits' (b) weak constitution and (c) living in mosquito-infected area are the constant factors in all cases of malarial fever observed by us. We eliminate other factors like age, sex, nationality etc. as they are changing and accidental.

Bacon attaches great importance to this step. He says that we should be free from all prejudices, observe nature carefully and record our findings correctly in order to arrive at a correct inductive generalisation.

2. The next step is the framing of a hypothesis.

A hypothesis is a provisional supposition. It takes for granted for the time being, some important factor to be the cause. This supposition guides our further observation. Ability to frame a correct hypothesis is the work of a genius. Many people observed apples falling from trees; but it was Newton who framed the correct hypothesis of gravitation.

Let us suppose that we frame the hypothesis that unhealthy habits are the cause of Malaria. We should try to prove this to be the real cause of Malaria. Mill has given five methods to prove causal connection. If our supposition is proved to be wrong, we discard this hypothesis, frame another hypothesis and try to prove it.

In the case of malarial fever, we find that living in mosquito infected area is the correct hypothesis. Further, it can be proved that Anopheles, a kind of mosquito, is responsible for this fever.

Whewell attaches great importance to this step. He says that the main business of Induction is over, when a legitimate hypothesis is framed.

3. The next step is generalisation.

Something may be proved to be the cause in some particular instances; but unless the assumed cause is true in every similar instance of past, present and future, it cannot be useful as a scientific law. There will be no advancement of knowledge unless we generalise the result of our observation. So we should pass from the observed to the unobserved, from the known to the unknown, wherever it is not necessarily confined to the particular case under examination. This involves a leap in the dark, a risk.

In our example, we should, therefore, pass from a statement like "In some observed cases, biting of Anopheles is the cause of Malaria" to a statement like "In all cases, biting of Anopheles is the cause of Malaria".

Mill attaches great importance to this step. He says that if this leap be absent, the process is not an Induction proper.

4. The last step in the Inductive procedure is verification.

Verification may be direct or indirect. In direct verification we try to find out cases where the supposed cause directly produces the effect. In indirect verification the evidence is such that we can legitimately infer the production of the effect from the supposed cause. In this case direct evidence is lacking. When verified, an inductive generalisation becomes a scientific law.

Jevons attaches great importance to this step. According to him a general proposition cannot be called an Induction, unless it is verified.

Verification involves some amount of deduction. We deduce conclusions from the general proposition and compare them with facts. So some Logicians have distinguished between Pure Inductive Method and Complete Method. Pure Inductive Method does not include the last step. i.e., verification. But Complete or Combined Method includes verification. It should be remarked that Induction in the modern sense cannot omit the last step, and the so-called Pure Inductive Method cannot fulfil the aim of Induction.

Relation of Induction to Deduction

Deduction is defined as the establishment of a proposition from more or equally general propositions in accordance with principles of Implication,e.g.,

(i) All men are mortal.
All students are men.
∴ All students are mortal.

(ii) All men are mortal.
∴ No men are immortal.

Induction is defined as the establishment of the material truth of a general real proposition on an examination of some particular instances in reliance on the Law of Uniformity of Nature, e.g.,

Ram is mortal.
Sita is mortal.
Akbar is mortal.
Alice is mortal.
....
....
∴ All men are mortal.

The following are the points of similarity between them.

(1) Both are forms of reasoning. In both we pass from one or more premises to a conclusion.

(2) In both there is advancement of knowledge, if we employ the reasoning to concrete cases. In both the cases we pass from something known to something unknown.

(3) In both the cases similarity is the ground of our inference. In the former case, we passed on from our knowledge of all men to a knowledge of some men. i.e., students. In the latter case, we passed on from our knowledge of some men to all men. In no case we can pass from our knowledge of man to a knowledge of stars.

The following are the points of distinction between them.

(1) In Deduction we need not examine the material truth of the premises. Assuming them as true we consider what follows from

them. In induction we examine the material truth of the premises. They are derived from experience. We assume that, "All men are mortal" is true and deduce conclusions from it in Deduction. But we learn from experience that Ram, Sita, Akbar etc. are mortal and proceed to draw the conclusion 'All men are mortal' in Induction.

(2) In Deduction we establish formal truth only. We try to find out what is implied by the premises and necessarily follows from them. In Induction our aim is to establish both formal and material truth. The conclusion should be justified by the premises and should be true as a matter of fact.

All men are immortal.
Ram is a man.
∴ Ram is immortal.

It is a valid deductive reasoning, though the major premise and the conclusion are materially false. But in Induction, we can never establish a proposition like 'All men are immortal', because it is not possible to find adequate premises for this.

(3) In Deduction the conclusion is never more general than the premises. It may be equally general, e.g., example (i) or less general e.g., example (ii) But in Induction the conclusion is always more general, e.g., the example of induction given above.

(4) The conclusion of a valid deductive argument cannot be false, when the premises are true. But the conclusion of even the best form of inductive argument may turn out to be false, in spite of the premises being true. So different inductive arguments have only different degrees of probability, while a deductive argument can assure us of absolute certainty.

The relation between Deduction and Induction has been described differently by different logicians.

(1) Jevons says : "It is the inversion of deduction which constitutes induction". According to Jevons, Deduction is a direct process. In a syllogism, we pass from a general truth to a case illustrating it directly. There is no guesswork here. If all men are

mortal and Ram is man, Ram is necessarily mortal. The progress is straight from the premise to the conclusion, from the ground to the consequent. But in Induction we get from experience—Ram is mortal, Sita is mortal, Akbar in mortal etc. We guess that 'All men are mortal' and again verify the truth of this proposition by deducing conclusions from it. So here the progress is not straight from the ground to its consequent. We proceed back to the ground from the consequent and again proceed from the ground to the consequent at the stage of verification. So Induction is the inverse process of Deduction.

This view suggests that the conclusion in Deduction is definite and certain, but the conclusion in Induction is indefinite and uncertain. Further, this description seeks to emphasise that deduction is prior to induction. These suggestions are misleading. The result of induction is probable but not uncertain in the sense of being not definite in its formulation. Again, there is no question of the priority of the one over the other.

(2) Some logicians have said that of Deduction and Induction, one is the converse of the other. It is so, because in one we pass from the general to the particular, from more general to the less general,but in the other we pass from the particular to the general, from less general to the more general.

This view suggests that one is merely the opposite process of the other. But besides this difference, Deduction aims at only formal truth whereas Induction aims at both formal and material truth. So one cannot be said to be just the converse of the other.

(3) Bacon says that Induction is an ascending process and Deduction is a descending process.

The process of establishing an inductive generalisation is like climbing a hill, which is difficult, but it enables us to have a broader view. On the other hand, the process of deduction is like descending from the hill, which is easy, but it confines our view to particular cases.

(4) Fowler says that Induction proceeds from effects to causes and Deduction proceeds from causes to effects because the general proposition established by Induction explains the facts of experience from which it is derived.

These descriptions suggest that one is the reverse of the other. But Deduction and Induction are not just opposite of each other. They have fundamental points of distinction, but they are complementary of each other.

Right view of the relation between Deduction and Induction

The above remarks of the different logicians are misleading, because they lead us to believe that Deduction and Induction are opposite and incompatible.

It is true that Deduction and Induction differ in their starting point. But both show the connection between parts and the whole. Both are based on similarity. Welton, therefore, rightly remarks : "There is no opposition between deductive and inductive reasoning". The difference in their procedure is due to the nature of the circumstances present before us. A medical scientist, before whom there are several cases of malarial fever, employs Induction to find out its cause or to discover a medicine to cure the fever. But when a doctor learns that Quinine cures malaria, he employs Deduction to cure his patients suffering from this disease.

In fact, it is true to say that one is complementary of the other. Without Induction the conclusion of Deduction will lack material truth and will not be of much practical utility in our life. Without Deduction, Inductive generalisation will lack verification and cannot be raised to the level of scientific law which is really reliable.

To solve complicated problems, as the case of the malarial fever cited above, we take the help of both Induction and Deduction, each supplementing the other.

Is Induction prior to Deduction ?

Logicians differ in their opinions on this point.

Mill holds the view that Induction is prior to Deduction. Induction first establishes the general proposition. Then Deduction applies this proposition to particular cases. So Induction is prior to Deduction.

Jevons holds the view that Deduction is prior to Induction. From facts of experience, we have the insight of a general proposition in the form of a hypothesis. When the hypothesis is verified,it becomes an Inductive Generalisation. Induction is not complete without prior Deduction at the stage of verification. So Deduction is prior to Induction.

It may be said, however, that Deduction and Induction are mutually dependent on each other. They are the two aspects of the same inferential process. So the question of absolute priority of one over the other does not arise. In actual practice one may precede the other depending on the nature of the case in hand.

Is Deduction more fundamental than Induction ?

Logicians differ in their opinions on this point.

Hamilton and Mansel hold the view that Deduction is more fundamental than Induction, because the typical reasoning is syllogistic. According to them, Induction also can be expressed in a syllogistic form, and so Deduction is more fundamental than Induction.

Mill and Bain hold the view that Induction is more fundamental than Deduction. According to them, in every scientific investigation we proceed inductively. Deduction is only a partial stage in the Inductive process. It applies general pinciples established by Induction in particular cases. So Induction is more fundamental than Deduction.

It may be said, however, that both these views are extreme and so unacceptable. Deduction and Induction are equally fundamental processes and neither can be reduced to the other without distortion.

By the use of symbols and of improved techniques traditional logic has grown into symbolic logic, where deduction is of primary concern. Pure logic as a formal science of implication need not include induction in its scope. But if we use the term 'Logic' in the broad sense and divide it into deduction and induction we cannot consider any of them to be more fundamental than the other, as each of them has fundamental points of distinction and a different purpose to serve.

EXERCISE

1. What is the nature of Inductive Logic ?
2. What is the necessity of Induction in Logic ?
3. What is the problem of Induction ? How is it solved ?
4. Explain the different steps in the Inductive procedure with a concrete example. How does the pure Inductive Method differ from the complete Method ?
5. Examine critically the following views :
   (a) "It is the inversion of deduction which constitutes induction".
   (b) "Induction and Deduction are complementary processes".
6. Define Primary Induction and indicate its nature.
7. What according to you is the right view regarding the relation between Deduction and Induction ?
8. "The difference between Deduction and Induction is not one of principle, but of starting point"—Discuss.
9. Show with concrete examples how Deduction and Induction are both necessary in our everyday life and in Science.
10. Of Deduction and Induction, which is prior and which is more fundamental ?
11. Define Secondary Induction and indicate its nature.

2

Induction Proper

In the history of Logic, we find many processes akin to Induction. Some of them are Inductions proper. Some others are not at all Inductions. They are Inductions improperly so called.

According to Mill, Inductions proper may be of three kinds :

(1) *Scientific Induction*—This is "Induction *par excellence* "—the best form of Induction.

(2) *Unscientific Induction*—It is "the kind of induction which is natural to the mind when unaccustomed to scientific method".

(3) *Analogy*—It is "some kind of argument supposed to be of an inductive nature but not amounting to a complete induction".

Mill distinguishes three kinds of inductions improperly so called :

(1) Perfect Induction

(2) Induction by parity of Reasoning

(3) Colligation of Facts.

1. Scientific Induction

Definition

Scientific Induction is the establishment of the material truth of a general real proposition on an examination of some particular instances in reliance on the law of Uniformity of Nature and the law of Causation.

Example :

Ram is mortal.
Sita is mortal.
Akbar is mortal.
Alice is mortal.
....
....
∴ All men are mortal.

Logical form of the reasoning

S_1, S_2, S_3,....................are P.
The cause of P is found in each of S_1, S_2, S_3,............
∴ All S's are P.

Nature or Characteristics

(1) Scientific Induction establishes a general real proposition.

A proposition states the relation between two terms. Scientific Induction is different from formation of a concept, because it establishes a proposition whereas in the formation of a concept only one term is involved.

A general proposition states something of an entire class of unlimited totality. Scientific Induction is different from Perfect Induction, because it establishes a general proposition of unlimited totality whereas Perfect Induction establishes an apparently general proposition, which is of limited totality.

A real proposition states in the predicate something different from the connotation of the subject term, whereas a verbal proposition states in the predicate the connotation or a part of the connotation of the subject term. Scientific Induction is different from Definition, because it establishes a real proposition whereas Definition gives the meaning of a term by a verbal proposition by stating the connotation of the subject in the predicate.

In the above example 'All men are mortal' is a general real proposition.

(2) Scientific Induction collects its premises from experience by an examination of particular instances. This may be done either by simple observation or by experiment. Scientific Induction aims at establishing the material truth of its conclusion. So the premises should be materially true.

Scientific Induction differs from Induction by Parity of Reasoning, because it is based on observation of material facts whereas the latter is not so based.

In the above example, we learn about the mortality of Ram, Sita etc. from experience by observation.

(3) Scientific Induction has an Inductive Leap.

The Inductive leap is considered by Mill and Bain to be the most important characteristic. Without this leap no process can be called an Induction proper. The leap means the passage from some to all, from known to unknown. Perfect Induction does not have this leap. So it is not considered to be an Induction proper.

In the above example, we pass from the mortality of some men to the mortality of all men.

(4) Scientific Induction relies on the law of Uniformity of Nature and the Law of Causation.

Law of Causation states that every event has a cause. Law of Uniformity of Nature states that Nature behaves uniformly.

So if a cause X produces the effect Y now, it must have produced Y in the past and will produce Y in the future.

In the above example, we first, relying on the Law of Causation,try to find out the cause of mortality. By the application of experimental methods we come to learn that 'having life' is the cause of mortality. Then relying on the Law of Uniformity of Nature we generalise and say that 'possession of life' produces death always. Now any individual to be considered as a man must possess life. So every man must possess life and consequently must be mortal. Thus we establish the proposition, 'All men are mortal'.

Value

Mill and Bain consider Scientific Induction to be the best form of Induction. It is called by Bain Complete Induction. It is based on a causal relation and so the conclusion is considered to be reliable and dependable.

The Scholastic Logicians named all inductions, where all the particulars covered by them are not examined, as Imperfect Inductions. They had no conception of Scientific Induction. But if we apply their terminology, Scientific Induction would be called Imperfect Induction, because it is impossible to examine all the instances covered by the general proposition. Carveth Read, therefore, names Scientific Induction as Imperfect Methodical Induction. The term 'Perfect Induction' is not applied to Scientific Induction, because it has come to mean, by the use of Scholastic Logicians, a process of generalisation, examining all the instances covered by the general proposition.

It should be noted that the term 'Scientific Induction' is used here in the sense in which Mill used it. This process of induction should not be confused with the 'process of induction used in present-day sciences'. It is realised these days that Mill's conception of both 'Science ' and 'Induction'is faulty. The primary function of science is not considered now- a-days to be limited to the discovery of causal connections and induction does not mean now-a-days only Primary Induction. The theories of present day science are established by the process of Secondary Induction,building up higher and higher systems. The term 'Scientific Induction' can be used to-day more properly to this process of establishing theories or non-instantial hypotheses.

2. Unscientific Induction

Definition

Unscientific Induction is the establishment of the material truth of a general real proposition on account of the uncontradictoriness of the instances experienced, in reliance on the law of Uniformity of Nature.

Example :

Lion A is tawny.
Lion B is tawny.
Lion C is tawny.

....

....

These are all the lions experienced so far.
∴ All lions are tawny.

Logical form of the reasoning

S_1, S_2, S_3, ...are P.
S_1, S_2, S_3, ...are all the observed instances of S.
∴ All S's are P.

Nature or Characteristics :

(1) Like the Scientific Induction, it establishes the material truth of a general real proposition. All lions are tawny is a proposition of the same type as "All men are mortal".

(2) Like Scientific Induction, it collects its premises from experience. But in Scientific Induction, a careful examination of a single case is sufficient for a complete generalisation, whereas in Unscientific Induction, the larger the number of instances observed and the more varying the circumstances of observation, the more the probability of the conclusion.

Unscientific Induction is called Induction per simple Enumeration, because the conclusion depends on mere enumeration or counting of instances. The enumeration, again, is imperfect or incomplete, because the general proposition is about an unlimited totality. So this is distinguished from perfect Induction or Induction by Complete Enumeration, where the general proposition is about a limited totality.

(3) Like Scientific Induction, it has an inductive leap. It passes from the observed to the unobserved, from the known to the unknown. Therefore, Mill takes it to be an Induction proper.

(4) Like Scientific Induction, it is based on our reliance on the law of Uniformity of Nature. It is because of this that we can pass from the observed cases to the unobserved cases. But by this it should not be meant that everybody, who generalises by this process, has a clear conception of the law of Uniformity of Nature. This is a popular form of generalisation and in our everyday life, we have many cases of generalisation of this sort. A child who has seen only red roses may think that all roses are red. An uneducated Negro in an African village may think that all men are black. They are not conscious of the law of Uniformity of Nature. But assumption of the law is implied in their generalisations.

Value

The generalisation in Scientific Induction is based on a causal connection.But no attempt to discover and prove a causal connection is made in unscientific induction. Neither we know that there is a causal connection nor do we know that there is no causal connection. So the conclusion here is only probable. If the number of instances observed is large, and no contrary instance is found, the probability is of a high degree. But unless the causal connection is proved, it cannot have the reliability of Scientific Induction. Unscientific Induction is called a *stepping stone* to Scientific Induction, because when a causal connection is discovered and proved it is raised to the status of Scientific Induction. For this reason, it is also called the starting point of Scientific Induction.

Bacon says, "Induction which proceeds by merely citing instances, is a *res puerilis* a childish affair". But most of the logicians do not consider all unscientific inductions to be so. It is the best that a layman can achieve. The probability of some cases of this form of induction is quite great where the positive instances are numerous and the likelihood of there being a negative instance is less. Grumley says, "The chief value of the enumerative method lies in its power to suggest causal relation...........Inductive enumeration, then, is not altogether worthless from the scientific point of view, it is at least a valuable aid to Induction proper".

It may be remarked that the scientific value of the generalisations arrived at by Induction per simple enumeration depends on the nature of resemblance among the members of the concerned class. For illustration, let us take the two generalisations: 'Lions are tawny' and 'Neighbours are helpful'. In the former case, we are taking a class of the 'Natural kind'. The members of this class resemble one another on numerous important points and their mutual difference is trivial. But in the latter case, 'neighbours' is an artificial class formed of people of all sorts grouped together only for their occupying residences near ours. So obviously the probability of the former being true is more than the latter. In any case, no attempt either to analyse the properties of the class or to connect these properties to the inferred quality is made in Induction per simple enumeration. So it is admitted to be a primitive process. But it must also be admitted that without simple enumeration science would never have begun.

3. Analogy

Definition

Analogy is a kind of probable inference from one particular to another based on their similarity.

Analogy comes from the Greek word 'Analogia', which was used by Aristotle to mean equality of ratios. Whately defines Analogy as "resemblance of ratios or relations". Mill says that Analogy is based on the formula :"Two things resemble each other in one or more respects; a certain proposition is true of the one; therefore it is true of the other". Bain says,"Analogy ....supposes that two things from resembling in a number of points, may resemble in some other point which is not known to be connected with the agreeing points by a law of Causation or of Co-existence". Carveth Read defines it as a "kind of probable proof based on imperfect similarity". Welton defines Analogy as "an inference from partial identity of content to further identity of content". Lotze says, the principle of Analogy is "of like things under like conditions, like assertions are true".

Example

Mars and the Earth resemble in many respects, e.g., both are planets of the Sun; both have land, sea, etc; both have atmosphere and temperature of similar type.

The Earth, further, has living beings.
∴ Mars has living beings .

Logical form of the reasoning

A &B resemble in the properties p, q, r, ...t.
A further possesses the property m.
∴ B possesses the property m.

Nature or Characteristics

(1) Analogy does not establish the material truth of a general real proposition explicitly as the other forms of Induction proper do. But a general proposition is implicit in this form of inference. We bring Mars and the Earth under the class 'all planets', which have similar qualities. In Analogy we explicitly pass from one particular instance to another particular instance. For this reason it is called an "incomplete induction."

(2) Like other forms of Induction proper, Analogy collects its premises from experience.

(3) Like other forms of Induction proper, Analogy has a 'leap'. We pass from known points of similarity to something unknown. For this reason, Mill includes Analogy in the group of Induction proper. The leap in other forms of Induction proper is with regard to the number of individuals, i.e., from some individuals to all individuals. But the leap in Analogy is with regard to the qualities or properties, i.e., from some similar qualities to other similar qualities. In other words, in Analogy we proceed from one individual having some qualities to that individual having more qualities, while in other forms of induction, we proceed from some individuals having one quality to all individuals having that quality.

(4) In Scientific Induction we establish a causal connection. In Unscientific Induction and in Analogy the knowledge of a causal connection is lacking.In the above example, we do not know whether there is any causal connection between life on Earth and its atmosphere, temperature etc. When a causal connection between them is proved, Analogy becomes Scientific Induction. It is for this reason that Analogy is called a *stepping-stone* to Scientific Induction.

(5) The conclusion of Scientific Induction is reliable and dependable ; but the conclusion of Analogy, like that of Unscientific Induction, is only probable. Probability may be of different degrees. In good Analogy, the probability is great. In bad Analogy, the probability is less.

Value or Strength of Analogy

Mill says, the value of an Analogy depends "on the extent of ascertained resemblance compared first with the amount of ascertained difference and next with the extent of unexplored region of unascertained properties." Bain says, "The probability is measured by comparing the number and importance of the points of agreement with the number and importance of the points of difference, having respect also to the extent of unknown properties as compared with known". Welton, however, says, "The force of an argument from Analogy depends on the character of identity and not on the amount of similarity". Similarly Bosanquet advises, "We must weigh the points of resemblance rather than count them."

The following rules have been suggested to determine the value or strength of an Analogy.

(1) The value of an Analogy is more, if the points of similarity are more in number and importance.

(2) The value of an Analogy is less, if the points of difference are more in number and importance.

(3) The value of an Analogy is less, if the unknown region is very much larger than the known region.

A point is considered important if it is relevant, and unimportant if it is irrelevant to the inferred quality, e.g.,land, sea, atmosphere and temperature are relevant to life, but size of the planet, proportion of land to sea and number of rivers and mountains are irrelevant to life.

Some logicians express the value of an Analogy by a fraction thus :

$$\frac{\text{Known points of Similarity}}{\text{Known points of Difference and Unknown points.}}$$

This fraction expresses the same idea as the rules stated above, because the value of a fraction increases when the numerator increases and it decreases when the denominator increases. But it should be pointed out that the value of analogy cannot be determined with mathematical precision, since the unknown points being unknown cannot be numerically determined.

It may be noted that the logical basis of analogical inference is the assumption that characteristics found together are connected with one another. It is because of this that the known points of similarity, or to use the terminology of J. M. Keynes, the known positive analogy leads us to the inferred similarity.

Further, the value of an analogy depends on the possibility of generalisation of the connection between the points of similarity, and the inferred similarity. For example, though we are concerned with only the Earth and the Mars in the above illustration, it should be possible for us to say that "All heavenly bodies which are planets of the Sun and have land, sea, atmosphere, moderate temperature etc. have living beings" .

Again, the probability of the inference becomes more, the less we infer in the conclusion. For example, instead of inferring the presence of living beings, if we infer the presence of human beings, on the Mars, the probability of the conclusion would certainly have been less.

Besides considering all the above points for determining the value of Analogy, it is also necessary to consider the importance of the known points of difference or what Keynes calls the known negative analogy.

So it should be evident that representing the value of an Analogy by a precise Mathematical fraction is misleading. However, considering all what has been said above, it is not impossible to determine roughly the value of an analogy and to declare whether it is good or bad.

A good Analogy is one where the points of similarity are more and important, the points of difference are less and unimportant, and the sphere of known points is very extensive. Here the probability is of a high degree.

A bad or false Analogy is one where the points of similarity are less and unimportant, the points of difference are more and important, and the sphere of known points is narrow. Here the probability is of a very low degree or nil.

Examples of good and bad Analogy

(1) Mars like the Earth may have living beings. This is considered to be a good Analogy by the Logicians.

(2) The Moon like the Earth may have living beings. The points of difference here are important and large in number. The Moon has no atmosphere and no water. Air and water are essential for living beings. So the probability is less.

(3) The Sun like the Earth may have living beings. The points of difference are important and large in number. The Sun is a gaseous body. Heat is extremely great. The probability is extremely less, rather nil. It is a bad Analogy.

(4) Lower animals, like men, feel pleasure and pain. Here the points of similarity are important and more.It is considered to be a good Analogy, if physical pleasure and pain are meant. It is of doubtful value, if mental pleasure and pain are meant.

(5) Radio receiving sets like men appear to talk and sing. So they are living. This is obviously a fantastic suggestion. It is a very bad Analogy proposed only by children.

(6) From the appearance of a twin brother, we infer by analogy that the other brother may be equally handsome.The points of similarity are important and more. This is a good Analogy.

(7) Of two new students from the same village, one is daring; therefore, the other may be so. The probability here is less. The known points are less than the unknown points. This is a bad Analogy.

(8) Jawaharlal and Lal Bahadur have both 'Lal' in their names. So Lal Bahadur is as efficient as Jawaharlal. The syllable 'Lal' is irrelevant to efficiency. It is a bad Analogy.

(9) Two pieces of cloth are made from the same stuff,from the same mill, by the same labourers, with the same texture, of the same thickness and used for the same purpose. One is not durable. Therefore, the other may be so. It is a good Analogy.Points of similarity are important and more.

(10) Ruler : State : : Captain : Ship.

Inhabitants of the State obey the ruler.

∴ Passengers of the ship should obey the Captain.

The argument has been made by resemblance of relations. This is according to the original meaning of Analogy. It is a bad Analogy.

Relation of Analogy to Induction and Deduction

There is difference of opinion among logicians regarding the exact relation of Analogy to induction and deduction. Some hold the view that Analogy is a form of induction, others maintain that both induction and deduction are based upon Analogy; some are of opinion that Analogy is a process of inference subsidiary to induction and some others hold that Analogy is a process involving both induction and deduction.

Those who consider Analogy as a form of induction assume that the essential characteristic of induction is the inductive leap or the

passage from the known to the unknown, from the observed to the unobserved. This characteristic is present in Analogy, since it passes from the known qualities of similarity to some unknown qualities of similarity. Of course, the leap in Analogy by connecting the observed quality with the inferred quality leading to the formation of a hypothesis is with regard to the qualities, whereas the leap in other forms of induction, *viz* , Scientific induction and Unscientific induction, is with regard to the individuals. But all the same, a leap is involved in all the three processes and the conclusion cannot be drawn unless the leap is taken. So, Analogy should be taken as a form of Induction Proper.

Those, who maintain that both induction and deduction are based upon Analogy, point out that it is analogy or similarity which is the basis of all forms of inference. It is the analogy or similarity of Ram, Sita, Akbar and Alice in essential characteristics which leads us to the conclusion that 'All men are mortal' by induction. Again, it is the analogy or similarity of Hari to all men which leads us to the conclusion that he too being a man must be mortal by deduction. No inference from men to stars is possible, since they are not analogous.

Those, who opine that Analogy is subsidiary to induction argue that Analogical inference is, by definition, a probable inference. The inferred quality is not known to be causally connected with the known points of similarity. When the causal connection is discovered, Analogy is raised to the rank of Scientific induction. Therefore, so long it remains as an analogical inference, it is only subsidiary to a complete form of induction.

Those who hold the view that Analogy is a process involving both induction and deduction analyse an analogical inference in the following manner :

Analogy— Two things A and B resemble each other in certain properties, *viz, x, y, z.*

A further possesses the property m.

∴ B possesses the property m.

Induction — The thing A which possesses the properties x, y, z also possesses the property m.

∴ All things which possess the properties x, y, z also possess the property m.

Deduction— All things which possess the properties x, y, z also possess the property m.

B possesses the properties x, y, z.

∴ B possesses the property m

It may be remarked that Analogy as a form of inference has such distinctive features that it deserves treatment different from both induction and deduction. The diversity of views enumerated above is mainly due to the laying of emphasis on different features. It should be remembered, however, that its affinity to induction is rather prominent and if it be reckoned as a form of induction, it is to be classified under the head Induction proper.

EXERCISE

1. Attempt a classification of the processes going by the name Induction and write short notes on each form of Induction proper.
2. Give a full account of Scientific Induction.
3. Why is Unscientific Induction called Induction per simple enumeration ? Assess its value.
4. Compare and contrast Scientific Induction with Unscientific Induction . Why is Scientific Induction called Induction *par excellence* ?
5. What is Analogy ? What are its characteristics ?
6. How do you determine the strength of an Analogical Inference ?
7. How is Analogy related to Induction ?
8. How do you distinguish between Good and Bad Analogy ? Give concrete examples.
9. Examine the following Analogical inferences and state with reasons whether they are good or bad :

   (a) All river lead to the ocean.
   All roads lead to Rome.
   ∴ All religions lead to God.

   (b) Both Lata Mangeskar and Usha Mangeskar have a melodious tone, are play-back singers and are Indians. Lata is rich. So Usha is also rich.

   (c) An individual has birth, growth and death. So every nation must come to an end.

   (d) Disproportionate growth of a limb disfigures the body. So enlargement of a colony is injurious to the state.

   (e) War is necessary for the healthy growth of a state, since it is an exercise and exercise improves health.

10. Explain what sort of reasoning is used to make the following statements :

   (a) All men seek happiness.
   (b) All cases of malaria fever are cured by quinine.
   (c) As long as the Earth rotates from west to east, the Sun will rise in the east.
   (d) Sky is sad in the rainy season.
   (e) Honesty leads to poverty.

3

Induction Improperly So-called

Inductions improperly so-called are processess which appear like Inductions, but differ from Induction proper in essential characteristics. They are called "processes simulating Induction", because they simulate or pretend to be Induction without actually being so. They have the 'semblance of Induction' but in reality they differ from it.

According to Mill no process can be called Induction proper, unless it has the Inductive Leap. According to him, Perfect Induction, Induction by Parity of Reasoning and Colligation of facts do not have Inductive Leap. So these are Inductions improperly so-called or Processes simulating Induction.

Further, it may be pointed out that observation of facts is an essential characteristic of Induction. Induction establishes a general and real proposition. In order that the proposition be general, inductive leap is essential and that the proposition be real, observation is essential. Necessity for observation also distinguishes induction from deduction. Deduction is possible with supposed statements which may not be true but Induction starts with observed facts which should be true to lead to a conclusion which must be real. In fact, Induction is derived from a Greek word which means counting, thus implying empirical content of Induction.

1. Perfect Induction or Induction by Complete Enumeration

Definition

Perfect Induction is the establishment of the material truth of a universal proposition on an examination of all the particulars covered by it.

Example :

January contains less than 32 days.
February contains less than 32 days.
March contains less than 32 days.
. . . .
. . . .
December contains less than 32 days.
∴ All the months of the year contain less than 32 days.

Logical form of reasoning

$S_1, S_2, S_3, \ldots\ldots S_n$ is P.
All S's = $S_1 + S_2 + S_3 \ldots\ldots + S_n$
∴ All S's are P..

Nature or Characteristics

(1) It establishes the material truth of a universal proposition. A universal proposition is distinguished from a general proposition. A general proposition is about an unlimited totality, *i.e.*, the number of instances covered by it is unlimited. But a universal proposition is about a limited totality, i.e., the number of instances covered by it is limited. Some logicians use the term 'universal' in the sense of 'general'. But in any case, we should understand that the proposition established by Perfect Induction is of limited totality or of restricted generality. Sometimes the term 'apparently general' is used to indicate this characteristic.

A year contains only twelve months. We examine each month and come to know that each month contains less than 32 days. So we get the universal proposition : All months of the year contain less than 32 days.

(2) Like other forms of Induction, Perfect Induction collects its premises from experience. The number of instances being limited, it can exhaust all the instances. For this reason, the conclusion of Perfect Induction is certain. The Scholastic Logicians of the Middle Ages considered it to be the best form of Induction. They distinguished it from the Imperfect Inductions, where all the instan-

ces have not been examined. This is also called Induction by Complete Enumeration, because enumeration or counting of the instances is complete here. From this consideration, it is distinguished from Induction by simple enumeration or Unscientific Induction, where the enumeration cannot be complete.

(3) In Perfect Induction, there is no Inductive Leap. There is no passage from known to the unknown. The instances being limited, we first know about each one of them and then express our knowledge by a universal proposition. Mill does not consider it to be an Induction proper, because it lacks this leap.

(4) The question of relying on the law of Uniformity of Nature or the law of Causation does not arise here, because the certainty of its conclusion depends on completely exhausting the examination of every instance and not on any causal connection. No reference to the law of Uniformity of Nature is necessary here, because we do not pass from the present cases to the past or future cases. We state about only those which we have examined.

Value

According to some logicians, Perfect Induction is neither Perfect nor Induction.

Grumley says, "Even when counting is complete it does not give us scientific knowledge." In Perfect Induction we may examine all the instances, and find a characteristic to be present in each instance, but still, it may be an accidental characteristic. So it does not necessarily give us any knowledge regarding the essential nature of the things examined. We examine all the students of a particular class one day and find that they have put on white dresses. From the standpoint of science this knowledge is not of much value. In Scientific Induction, on the other hand, we establish a causal relation with an essential quality of things, which extends our knowledge to the remote past and the distant future.

Mill and Bain say that Perfect Induction is not at all Induction. Bain says that in Perfect Induction, there is "no real inference........no addition to our knowledge". Mill says it to be "a mere

shorthand registration of facts known." There is no advancement of knowledge at all, because it does not establish a really general proposition.

Perfect Induction has been described as a *summary Induction*. It summarises the premises in the conclusion.The conclusion is only nominal stating nothing new but what has already been stated in the premises.

Jevons, however, says that the certainty of Perfect Induction cannot be reached by other forms of Induction. The conclusions of other forms of Induction may be highly probable but never absolutely certain as in the case of perfect Induction. So Perfect Induction is really perfect in this respect.

Dr. P. K. Ray contends the views of Mill and Bain. According to him, Perfect Induction is an Induction proper, because here also we rely on the law of Uniformity of Nature. We examine all the known planets of the Sun, and come to the conclusion by Perfect Induction that they receive light from the Sun.We believe in this statement not only when we examined them, but we also believe now and will believe in future. We believe that the planets received light from the Sun before the examination began and will continue to do so after the examination.So there is a leap in respect of time.

In any case, logicians do not consider Perfect Induction to be altogether useless."The power of expressing a great number of particular facts in a very brief space is essential to the progress of Science." Perfect Induction does at least this, if nothing else besides.

2. Induction by Parity of Reasoning

Definition

Induction by Parity of Reasoning is the generalisation of a truth arrived at by reasoning in a typical case on the ground that the same reasoning will hold good in every other similar case.

Example :

We prove geometrically in the case of a particular equilateral triangle that the angles are equal.

∴ All equilateral triangles are equiangular.

We prove algebraically $(a+b)^2 = a^2 + b^2 + 2ab$.

∴ The sum of the square of any two numbers is equal to the sum of their squares plus twice their product.

Logical form of the reasoning

S_1 (being x) is necessarily p.

∴ All S's (being each x) are p.

Characteristics

(1) Induction by Parity of Reasoning establishes a general mathematical proposition.

The conclusion of Induction by Parity of Reasoning is a general proposition because it states about all things (geometrical diagrams,mathematical expressions) of a particular type. It may be taken as a real proposition in the sense that it does not state merely the connotation or a part of the connotation of the subject term. In that case no proof is necessary. It rather states some property which can be deduced from the definition of the subject term. The conclusion, however, is not a real proposition in the sense of being based on observation of natural facts.

(2) It is not based on observation of facts. A geometrical diagram or a mathematical expression is not a concrete fact of experience. It rather represents a concept. The diagram of a triangle stands for all triangles at once. The sides may be of any length; the angles may be of any size. The only limitations are by definition, that it must be a plane figure bounded by only three straight lines. So whatever is deduced from these limiting characteristics must be true of all diagrams of triangles. Similarly, 'a' and 'b' in the above algebraical formula represent any two quantities.

(3) There is no Inductive Leap here. It may appear that we are passing from one diagram to all diagrams of the same sort and so there is the Leap. But as stated above, the diagram of a triangle stands for all triangles at once and so whatever statement is made about this diagram is a statement about all diagrams of triangles.

Similarly, whatever is true of $(a+b)^2$ is true of the square of the sum of any two numbers. For this reason Induction by Parity of Reasoning is not considered to be an Induction proper.

(4) The question of relying on the Laws of Uniformity of Nature and the Law of Causation does not arise here, because we are not dealing with concrete facts of Nature. The necessary connection in this case is derived from the postulates of the mathematical system and the properties of figures and numbers.

Value

Induction by parity of Reasoning is considered by logicians to be deductive rather than inductive. The conclusion is deduced from the definition of the subject term, the axioms and theorems. To prove the equiangularity of equilateral triangles we take the help of the theorem : "If two triangles have two sides of the one equal to two sides of the other, each to each, and the angles included by those sides equal, then the triangles are equal in all respects" or of the theorem : "The angles at the base of an isosceles triangle are equal." Thus Induction by Parity of Reasoning is purely deductive.

This form of reasoning, however, should not be confused with another form of reasoning which may be regarded as inductive. We measure the angles of several equilateral triangles and find that the angles are 60° each. From this result, we generalise and state that "All equilateral triangles are equiangular". Here the conclusion is established by a form of Induction by simple Enumeration.

Induction by Parity of Reasoning is not at all useless simply because it lacks the characteristics of an Induction proper. Geometrical and mathematical reasonings give us absolutely certain conclusions and are very useful in scientific investigation.

3.0 Colligation of Facts

Definition

Colligation of Facts is the formation of a concept by colligating or binding together a set of observed facts.

Mill defines Colligation of Facts as "that mental operation which enables us to bring a number of actually observed phenomena under a description, or which enables us to sum up a number of details in a single proposition".

Example :

A sailor goes in a ship along the coast of a piece of land and arrived at the place he started from.

∴ The piece of land is an island.

Logical form of the reasoning

S has the properties x, y, z.
Whatever has the properties x, y, z is p.
∴ S is p.

Characteristics

(1) Colligation may be illustrated in formation of Concept or Classification.

As an illustration of formation of Concept, Colligation of Facts is the establishment of a notion and not a proposition. As an illustration of Classification, it is the bringing of an individual fact under a concept. An experienced fact may be expressed by a singular proposition, e.g., the piece of land is an island or this is an island. But still the mental operation here is concerned only with one concept, i.e., the island.

(2) It is based on observation of facts. The sailor, in the above example, observes every point of the course. Kepler observed only some of the positions of Mars in its orbit and came to the conclusion that the orbit is elliptical. In each case, however, the observed facts are combined by a concept.

(3) In the case of Colligation as an illustration of Classification, there is no question of Inductive Leap. This form of Colligation of Facts is more deductive than inductive in nature, e.g., the example given above may be stated in the form of a syllogism thus :

A piece of land surrounded by water is an island.
This is a piece of land surrounded by water.
∴ This is an island

The minor premise of the syllogism is obtained by observation and so the process is not purely formal or deductive.

(4) There is no question of reliance on the Law of Uniformity of Nature or the Law of Causation in cases of Colligation of the above sort.

Colligation of Facts describes observed facts. There is no attempt at explanation of facts. Scientific Induction, on the other hand, does not simply describe that men are mortal but explains as to why they are mortal.

Value

Mill is of opinion that Colligation of Facts is not at all Induction. There is no inference from facts observed to facts unobserved in the above example. The sailor merely describes the facts observed by a concept which he earlier had. But in Induction there is always a passage from the observed to the unobserved yielding a proposition. Further, Colligation is merely a description whereas Induction is an explanation. In Induction we explain why men are mortal and not simply state that they are mortal.

Whewell is of opinion that Colligation is the same as Induction. In every form of Induction we colligate or unite facts under a suitable concept. We observe several facts of mortality of Ram, Sita, Akbar etc., and unite them under the complex concept of mortality of man. The essence of Induction lies in the mental faculty of superimposing a concept upon facts. The difference in the opinions of Whewell and Mill is due to their views on Induction. Whewell regards Induction as essentially an art of discovery and stresses the importance of hypothesis. But Mill regards Induction as essentially a science of proof and stresses the importance of explanation.

It may be remarked that it is not proper to hold that all processes which colligate facts are Inductions. Description, Definition and Classification also colligate facts, but they are not Induc-

tions. So Mill appears to be correct in his observation : "Induction is Colligation", but "Colligation is not necessarily Induction".

It should be added, however, that formation of concept is an essential process in scientific procedure and so the importance of Colligation of Facts cannot be ignored.

No Induction is possible without prior Colligation of Facts by way of forming concepts, because Induction as a process of establishing a general proposition, i. e., a relation between two concepts, presupposes a prior colligation of individual facts.

Mill, therefore, concludes that Colligation is a "process subsidiary to Induction", a necessary preliminary to Induction, but by itself falls short of Induction.

EXERCISE

1. What are the processes simulating Induction ? Write a short note on each of these processes.
2. What is Perfect Induction ? Why is it not considered to be an Induction proper ?
3. Compare and contrast the two forms of enumerative Induction.
4. Explain why Perfect Induction is said to be neither perfect nor induction.
5. Why is Induction by Parity of Reasoning is said to be deductive rather than inductive ?
6. Explain the characteristics of Induction by Parity of Reasoning. Does it contain the "Inductive leap" ?
7. Give a complete account of Colligation of Facts.
8. "Induction is Colligation, but Colligation of facts is not Induction"— Explain.
9. Examine Critically :
   (a) the view of Jevons on the value of Perfect Induction.
   (b) the view of Dr. P.K.Ray on Perfect Induction being an Induction proper.
   (c) the view of Whewell on Colligation being the same as Induction.
10. Explain the reasoning in the following cases :
   (a) You enquire about the religious beliefs of the inhabitants of a village and come to the conclusion that all the people of the village are Muslims.
   (b) You draw six equilateral triangles on a piece of paper, measure the angles and come to the conclusion that all equilateral triangles have equal angles.
   (c) You draw a square and prove geometrically that the diagonals are equal. Then you conclude that in every square the diagonals are equal.
   (d) You collect the torn pieces of an unknown picture; you adjust the pieces with one another and reconstruct the picture. Now, you know that it is the picture of a dog.
   (e) You lost your handkerchief and your brother found one. You examine and find it to be identical with the one you lost. You come to the conclusion that it is yours.

4

Grounds of Induction

Every inductive reasoning is of a certain form and is about some facts of experience. The form of Inductive reasoning is a passage from some to all. The matter of Inductive reasoning is the facts of experience. According to Mill the passage from some to all is justified by two presuppositions, viz, the law of Uniformity of Nature and the Law of Universal Causation. The facts of experience are obtained by Observation and Experiment. So the formal grounds of Induction are the Law of Uniformity of Nature and the Law of Universal Causation and the material grounds are Observation and Experiment.

The law of Uniformity of Nature

Coffey and Mellone distinguish between two forms of stating this law. In its categorical form it may be stated as "Nature is uniform" or "The course of Nature will be the same in future as it had been in the past." In its hypothetical form it may be stated thus : "If the same cause occurs, it will have the same effect" or "Nature behaves in the same way, when similar circumstances occur."

Whatever be the manner of its expression, Uniformity of Nature does not mean the repetition of a set of natural events. "Nobody believes that the succession of rain and fine weather wll be the same in every future years as in the present." (Mill). "The wind and the weather are proverbially uncertain; the course of trade or of politics is full of surprises." (Carveth Read). Uniformity of Nature, how-

ever, does mean that the essential nature of a thing remains just the same. The nature of water is to flow downwards. It will uniformly behave in the same manner unless there be any reason to behave differently. On analysis we find that events do not occur whimsically. For every event there are a number of conditions and whenever the conditions are present, the event must take place. Mill says, "There are such things in Nature as parallel cases, that what happens once, will, under a sufficient degree of similarity of circumstances, happen again, and not only again, but as often as the same circumstances recur".

The apparent irregularities of Nature like earthquake, eclipse etc. are also dependent on their causes. When these causes occur, these events also occur regularly. So there is no irregularity in Nature.

But sometimes the question is raised : Should we speak of a Uniformity in Nature or rather hold that there are different Uniformities in different departments of Nature ? Bain says, "The course of the world is not a Uniformity but Uniformities". Mill classifies these Uniformities or laws under the heads of (i) Co-existence, (ii) Succession and (iii) Similarity. Bain speaks of (i) Co-existence, (ii) Sequence and (iii) Equality or Inequality. But since these Uniformities are parts of one organised whole, the expression '*Unity of Nature*' is preferred to Uniformity or Uniformities of Nature. Nature is a Unity in variety, a cosmos and not a chaos.

According to Mill and Bain, the Law of Uniformity of Nature is the formal ground of all forms of Induction whether scientific or not. Bain says, "The fact of Nature's uniformity is the guarantee, the ultimate major premise, of all induction." The Inductive argument may be put in the form of a syllogism, if we take the law to be the major premise. The induction concerning 'All men are mortal' can be put in the following form by taking a special application of the law of Uniformity of Nature as the major premise and the facts of experience as the minor premise thus :

∵ Whatever is true of Ram, Sita, Akbar etc. is true of all men.
Mortality is true of Ram, Sita, Akbar etc.
∴ Mortality is true of all men.
(i.e., All men are mortal.)

Paradox of Induction

Paradox is an absurd or self-contradictory statement. Regarding the origin of our knowledge about the Law of Uniformity of Nature, the empiricists like Mill and Bain give a paradoxical statement. They say that, "the ground of Induction is itself an induction". This is known as the Paradox of Induction.

Mill says that the Law of Uniformity of Nature is a "fundamental principle or general axiom of Induction". It is according to him, "an assumption implied in every case of Induction". Again he holds that the Law of Uniformity of Nature is "itself an instance of Induction". It is "itself founded on prior generalisations." According to the empiricists all our knowledge is derived from experience. All knowledge is *a posteriori*, i. e, posterior to or after experience. So we have the knowledge of Uniformity of Nature from experience thus :

Nature behaves uniformly in the Department of Physics.
Nature behaves uniformly in the Department of Chemistry.
Nature behaves uniformly in the Department of Astronomy.
....
....
....
∴ Nature behaves uniformly everywhere.

From 'particular uniformities' we infer 'a general uniformity' by Induction per Simple Enumeration. When thus the knowledge of the law of Uniformity of Nature is derived, it becomes the ground of all forms of Induction, scientific and unscientific. This is the Paradox of Induction.

Criticism

(1) Mill's argument commits the fallacy of *petitio principii*. It means he assumes the very thing which he wishes to prove. He

proves the Law of Uniformity of Nature by Induction per Simple Enumeration. But how does he pass from some observed cases of Uniformity of Nature to Uniformity of Nature in all cases ? Obviously, he does so by the law of Uniformity of Nature. Inductive Leap is justified by the Law of Uniformity of Nature. Unless we assume the law, we cannot pass from some to all. So here we prove the law of Uniformity of Nature with the help of the law of Uniformity of Nature. This is absurd.

(2) From probability of a lower order we cannot deduce probability of a higher order. If the law of Uniformity of Nature is established by Induction per Simple Enumeration, its probability is of a lower order than that of the conclusion of Scientific Induction. But according to Mill, law of the Uniformity of Nature is the fundamental assumption, the major premise of all kinds of inductive argument including Scientific Induction. How can the conclusion be stronger than the premise in respect of probability ?

In conclusion, it may be said that a fundamental assumption regarding the constitution of the universe as is the law of Uniformity of Nature cannot be proved. It cannot be proved deductively because there is no principle higher than it from which it can be deduced. It cannot be proved inductively, because it is assumed in the very process of inductive reasoning.

It may be mentioned here that those like Mill and Bain, who hold all our knowledge to be derivable from experience, are called the empiricists and their theory is called a posteriori theory. We have seen that the empiricists' attempt to prove the law of Uniformity of Nature ends in a failure. So the a posteriori theory of the law of Uniformity of Nature is unacceptable.

There are some others, called the rationalists, who hold that some knowledge at least is innate, i.e., in our mind from the very birth. Their theory is called the a priori theory. According to them, the law of the Uniformity of Nature is an innate principle, which is axiomatic and self-evident. This view also is unacceptable. The

manner in which we become conscious of the law of the Uniformity of Nature disproves its being an innate principle. Again, it cannot be axiomatic and self-evident, since its opposite does not lead to any contradiction.

Kant's suggestion that it is a necessary precondition of knowledge and so must be taken as true is also not considered helpful for an account of the law of Uniformity of Nature.

Joseph's attempt to deduce it from a recognised axiomatic principle, i.e., the law of Identity is also not considered to be convincing.

So all that we can say about the law of Uniformity of Nature is that it is only a very useful assumption largely supported by empirical evidence and helpful in our making generalisations and giving predictions.

Science to-day does not stand in the need of believing in this assumption. The belief that is essential in science is that nature is a system of laws, which are simple enough to be discovered by human intellect.

Law of Universal Causation

The Law of Universal Causation may be stated as "Every event has a cause" or "Whatever happens has a cause". Mill states it as "Every phenomenon which has a beginning must have a cause".

The Law of Universal Causation denies the coming out of anything from nothing. "*Ex nihilo nihil fit* " i.e., "Out of nothing nothing comes". We may not know the cause of some occurrence, but that does not mean that it has no cause.

A man is found dead. If *post mortem* examination fails to specify anything as the cause of his death, it does not mean that the death in this case has no cause.

The Law of Universal Causation states that every event has a cause, but from this we cannot know that bite of anopheles is the cause of malaria or heat is the cause melting of ice. Establishing such

causal laws depends on observation of facts and the law of Uniformity of Nature. The law of Universal Causation as stated above also does not imply that the same cause produces the same effect always. For such a formulation, we have to take the help of the law of Uniformity of Nature.

Formulating the law of Causation as 'every event has a cause', Sigwart and Welton take the law of Causation to be independent of the law of Uniformity of Nature.

Mill and Bain, however, formulate the law of Causation as 'the same cause produces the same effect always' and take it to be a form of the law of Uniformity of Nature. According to them, Uniformity of succession is the same as the law of Causation.

According to Mill,the law of Causation is the formal ground of Scientific Induction. Every form of induction is based on the law of Uniformity of Nature, since we pass from some cases (observed) of a class of things to all cases (observed or unobserved) of that class of things. In Scientific Induction this generalisation is strengthened by the discovery of a causal connection.

We have observed crows and found them to be black. Basing on the law of Uniformity of Nature, we generalise and conclude that "All crows are black". This is Induction per Simple Enumeration. There is co–existence between crows and blackness, but we do not know why they are black. Now, suppose scientists are able to discover why some birds are black, while others are not. If that cause be an essential characteristic of every crow, so that without that characteristic, it cannot be taken as a crow, then the strength of the generalisation 'All crows are black' increases. So according to Mill the universality of an inductive conclusion is based on the law of Uniformity of Nature but its strength depends on the law of Causation.

According to Mill the law of Universal Causation can be inductively established by taking note of several cases of uniformity of succession. This is the empiricistic or a posteriori view on the law of Universal Causation.

According to others, it is an a priori principle taken for granted to be always true. No amount of empirical evidence can disprove it. Even if we fail to discover the causes of some phenomena we do not discard the law of Universal Causation. We attribute our failure to lack of adequate knowledge.

According to some others again, it is not a proposition that need be true or false. It is a proposal that works in practice very satisfactorily and helps in making predictions for the guidance of our life.

Observation

Observation is regulated perception of facts and events under natural circumstances for a definite purpose without any bias.

Perception is of two kinds—external perception and internal perception. External perception is what gives the knowledge of facts and events with our sense organs. Internal perception is also called introspection. It is what gives the knowledge of our own mental states.

In observation we have a definite purpose. The purpose regulates our observations. It becomes selective. We select significant facts or significant aspects of facts for observation which are relevant to our purpose. No fact or any of its aspects is significant by itself. It is significant or insignificant in view of our purpose. In a theft case, for the purpose of identifying the thief, footprints and fingerprints are significant, but for the purpose of determining the worth of the stolen property, they are insignificant. For giving a presentation personally, the colour aspect of the packing material may be significant. But for sending it by post, the strength aspect of the packing material is significant.

Observation should be undertaken without any bias or prejudice. Bacon says that we should be free from 'idolas' or preconceived notions while observing. In a case of theft, if we are prejudiced against a particular man, we may be observing only his behaviour ignoring other factors essentially connected with the case.

Observation should not be confused with inferences from it. Jevons says, "So long as we only record and describe what our senses have actually witnessed, we cannot commit an error; but the moment we presume or infer anything we are liable to mistake". The sun appears like a ball with a diameter of just a few inches. The statement is absolutely correct. But if we infer from this that the sun is actually not bigger than that, we are mistaken.

Ordinarily, we observe things with our natural sense organs. But our sense organs are of limited capacity. Minute germs cannot be seen by naked eyes. Stars at a very great distance also cannot be seen. Very low sounds cannot be heard by our ears. Slight difference in temperature cannot be noticed. Scientists, therefore, make use of scientific instruments, which extend the field of observation and increase its accuracy. Now-a-days, microscopes, telescopes, tele-cameras, artificial satellites, tape–recorders etc. are used in scientific observation for proper observation and preservation of what is observed.

In simple observation, the objects of observation are unaffected and unchanged. They are observed as they occur in Nature under conditions presented by Nature. If we observe a plant every week for the purpose of recording its growth, it is simple observation. But when we make certain changes in its circumstances, e.g., giving different kinds of manure to note their effects on its growth or changing its place from a shaded part to a place exposed to sunshine to note the effect of such change, we are no longer having simple observation. It is experimental observation.

Experiment

Experiment or Experimental Observation is the observation of facts or phenomena for a definite purpose under conditions pre-arranged by us.

In experiment, the circumstances are under our control and we make things happen for proper investigation under known circumstances. Suppose, we wish to study the effect of a drug on animal

organism. We make arrangements for an experiment. The drug is given in measured doses to different kinds of animals. By noting their subsequent conditions, we will be in a position to know the effect of the drug on them.

In experiment, it is sometimes possible to create suitable circumstances to artificially reproduce the phenomenon under investigation in the laboratory. Here, we are the master of the situation and can vary the circumstances at our will. Electricity, for example, can be produced in the laboratory and we have no need to wait for its observation in the form of lightning. Similarly, the chemist produces water in the laboratory by combining Hydrogen and Oxygen in required proportion. Bain, therefore, describes Experiment as the *making* of a fact. Bacon says, "In experiment, we interrogate Nature". We cross examine her to get definite answers.

Relation between Observation and Experiment

The main distinction between Observation and Experiment is that in Observation the object of observation is presented by Nature under natural circumstances and we have no control over the situation; but in Experiment the object of observation is, in varying degrees, under our control. So long as we do not tamper with the object of observation or the circumstances, it is Observation. But the moment we bring about some changes in these, it is Experiment. In Observation, therefore, the result is less accurate and less certain. In Experiment, the result is more or less accurate and certain, depending upon the degree of control we have over the situation. Where the degree of control is very high, we artificially reproduce the event in the laboratory. It is, therefore, said that Observation is perception of natural events but Experiment is artificial reproduction of events. Bain says, "Observation is finding a fact and Experiment is making one".

Some logicians have stressed the difference to such an extent that they lead us to believe that Observation and Experiment differ in kind. This is wrong.

Some writers say that Observation is wholly natural and Experiment is wholly artificial. This view is unacceptable. Observation makes use of artificial scientific instruments to increase the capacity of our sense organs, and to that extent it is artificial. Experiment, on the other hand, makes use of our natural sense organs, and to that extent it is natural. It may be admitted that, Observation is more natural and Experiment is more artificial. But this is a difference in degree not in kind.

Some writers again e. g., Stock, say that Observation is "passive experience" and Experiment is "active experience". This view is also unacceptable. Observation is not passive reception of facts. We actively plan for the observation with a definite purpose. We actively select the relevant facts and eliminate the irrelevant ones. It is true that the degree of activity in Experiment is greater than that in Observation. But this is, again, a difference in degree, not in kind.

So we may conclude that Observation and Experiment do not differ in kind. There is no opposition between the two. The purpose of both is the same, i.e., knowledge of facts and events. The difference is that Observation depends on Nature more than Experiment and so the activity comparatively is low. The difference is in degree, not in kind. In fact, the process in every case is nothing but Observation, either simple or experimental.

Natural Experiment

Jevons gives the name 'Natural Experiment' to those cases of observation where Nature herself creates special circumstances for better observation and accurate knowledge of certain phenomena. Before the days of rockets, the shape of the Earth could be inferred, but not observed. At the time of lunar eclipse, the shadow of the Earth falls on the Moon. The shadow of the Earth can be observed only on that day and on no other day. Nature herself creates this favourable circumstance. So this is called Natural Experiment. Astronomers choose special time and special place for important

observations of the transit of planets. These are Natural Experiments.

Natural experiment may be said to occupy a midway position between simple observation and experiment. It makes observation under selected conditions but leaves the object of observation unaffected and so it cannot be called an Experiment in the ordinary sense of the term. It is more like observation than like experiment, so the name is inappropriate.

Advantages of Experiment over Observation

Experiment is preferred to observation for the following advantages :

(1) In Experiment we can multiply instances as often as we like.

In Observation we depend on Nature for the presentation of instances. So we have to wait till Nature gives us the opportunity. But in Experiment the object of observation is under our control. So we may have as many Experiments as we like. For the observation of a comet, we wait till Nature presents a comet and the opportunities in a life-time may not be many. But in order to have an experiment on electricity, we do not depend on Nature. We produce electricity in the laboratory. So we can have the experiments as many times as we like.

(2) In Experiment we can isolate the influence of a condition, whereas in Observation it is not possible.

Observation is of natural events under natural conditions. Nature presents phenomena under complex circumstances. There may be many unknown influences which cannot be detected. But Experiment is made under known circumstances. So it is possible to note the influence of a single agent by keeping the other agents constant. The stomach of a cat after a meal is observed through X-rays. The digestive function is found to be going on smoothly. A dog is brought to the laboratory and immediately the digestive function stops. The dog is taken out and some fifteen minutes after, the digestive function goes on again. So by experiment we have noted

the effect of anger or worry on digestion. Thus the effect of a particular agent, i. e., anger or worry is known on digestion. By putting a burning candle in a jar of Oxygen and by putting it again in a jar of Nitrogen, we know that Oxygen helps burning and Nitrogen puts it out.

(3) In Experiment we can vary the circumstances at will. If we observe a thing under various circumstances, we can know about it better. By this way, we can distinguish the essential features from the accidental ones. Varying the circumstances helps elimination. In experiment, we can place the object of observation under different situations according to our will. But in observation, it is not possible. In observation, Nature presents the phenomenon under circumstances which may not be advantageous for our purpose. Thus by varying the circumstances we can know that the average Memory span for adults with regard to number is 8 digits. By varying the circumstances in an experiment, we can know that Nitric Acid cannot dissolve gold though it dissolves other metals like silver, iron etc.

(4) Quantitative changes can be brought about by experiment but not by observation.

In medical science it is necessary to know what quantity of a drug is to be administered to the patients to get the best curative effect. This can be done only by experiments. The laws of the advanced sciences are expressed quantitatively. This cannot be done unless the data are collected by experiments. Accuracy and precision are important characteristics of scientific knowledge and only experiment can give such knowledge. So wherever possible, experiment is preferred to observation.

(5) In experiment we are not in a hurry and the result is more accurate and certain.

In observation, we are in a hurry, because Nature may withdraw the opportunity given to us at her will. The lightning appears and disappears without warning. If we are not ready, we miss the oppor-

tunity. The comet appears at long intervals. So if we lose an opportunity, we may not be able to observe it at all. But electricity can be produced in the laboratory at any time we like. So, we can observe it with care and caution. Cool and careful examination leads to accurate and certain results. If we have the least doubt, we can repeat the experiment and check our result. Fowler says, "To experiment is, not only to observe, but also to place the phenomenon under peculiarly favourable circumstances". Carveth Read says, "Experiment enables us to observe coolly and circumspectly and to be precise as to what happens". For all these advantages, sciences which collect materials by experiments make more rapid progress than those which depend on only simple observation.

Advantages of Observation over Experiment

Observation has the following advantages over experiment.

(1) Observation is universally applicable.

Experiment is limited in its scope. It is not possible in Astronomy, because heavenly bodies are not under our control. It is not morally justifiable where human lives are concerned. No experiment can be made to determine the effect of a poison on human body or the effect of a war on human society. In all such cases, we take recourse to observation when Nature provides the opportunity. Wherever experiment is possible observation is possible; but where observation is possible, experiment is not necessarily possible.

(2) In observation we can proceed from cause to effect or from effect to cause, but in experiment we proceed only from cause to effect.

Experiment is doing something; but observation is noting something. In experiment we introduce or take away something to see its effect. Thus it always proceeds from cause to effect. But in observation, we take note of facts. We relate phenomena causally. If an event 'X' is chosen, from its observed antecedents we can find out its cause, and from its observed consequents we can find out its effect. Thus observation proceeds both ways.

(3) Observation is possible without Experiment but Experiment is not possible without Observation.

We may observe anything around us just by directing attention to it. Experiment is not a necessary condition for observation. But observation is a necessary condition of every experiment. We wish to have an experiment on dogs. We wish to note the effect of a drug on them. It is by observation alone that we bring dogs and not cats to the laboratory. Again, it is by observation alone that we administer the particular drug, and no other, to the animals. By previous observation we know in a general way the facts and so adequate preparation for the experiment becomes possible. So no experiment is possible without observation.

Fallacies of Observation

The aim of observation, whether simple or experimental, is to have an adequate knowledge of facts or events for some definite purpose. Sometimes we arrive at faulty conclusions because of fallacious observation. These fallacies may be of two types. Mill says. "A fallacy of mis-observation (or imperfect observation) may be either negative or positive; either Non-observation or Mal-observation".

Non-observation

According to Mill, "It is Non-observation when the error consists in overlooking or neglecting facts or particulars which ought to have been observed." Observation is selective. It eliminates the inessential and concentrates on the essential. But unless selection and elimination are properly done, we are liable to errors.

A foreign visitor, during his short stay in India, visits a few Indian families and finds that they are rich and educated. From this, if he concludes that all Indians are rich and educated, he is entirely wrong. He is committing the fallacy of Non-observation of instances. He has not observed the innumerable Indian families which are poor and illiterate.

A private tutor has a long list of successful candidates who received coaching from him. From this, if we think that his coaching is the cause of success in the examination, we may be wrong, because we are ignoring the negative instances, if there be any,i.e., the candidates who failed in spite of his coaching.

The cause of burning of a thatched house is supposed to be the flame of a match stick. Here we are ignoring the dryness of the hay and committing the fallacy of Non-observation of essential circumstances. If the roof would have been dripping wet by a shower of rain, the burning match stick could not have set fire.

We attribute the failure of a student in the examination to the bad teaching in the College. Here, we ignore the student's neglect of studies and thus commit the fallacy of Non-observation of essential circumstances and ignore the success of other students by the same teaching and thus commit the fallacy of Non-observation of instances

Mal-observation

According to Mill,"It is Mal-observation when something is not simply unseen, but seen wrong; when the fact or phenomenon instead of being recognised for what it is in reality, is mistaken for something else."

We commit Mal-observation, because we mix up observation with inferences.

We see a rope in the dark but mistake it to be a snake. We see a stranger in the street but mistake him to be a friend because of some similarity between him and our friend. People who declare to have seen ghosts, perhaps see something which they interpret as ghost. A little careful examination sets these Mal-observations right. We unduly assume here that two things having some similarity are similar in all respects. Such a fallacy is called individual Mal-observation, because it is limited to the individual only. Others may not commit the same fallacy.

Some other cases of Mal-observation are due to the nature of our sense organ.

Parallel rail roads appear to be converging. A straight rod appears to be bent when immersed half in a glass of water. No amount of care and caution can set these observations right. The mistake that we commit here is inference from an undue assumption, i.e., 'what appears to be something, is really that thing' or 'what appears to be something from one standpoint will appear so from another standpoint.' Such fallacies are called universal Mal-observations, because everybody is liable to commit them.

EXERCISE

1. Explain the Law of Uniformity of Nature. Is there a Uniformity or many Uniformities in Natrue ?
2. What is paradox of Induction ? How is it solved ?
3. State and explain the Law of Causation. How is it related to the Law of Uniformity of Nature ?
4. What do you mean by Grounds of Induction ? Explain with the help of examples how, for its form and matter, Induction depends on its grounds.
5. What is Observation ? Explain its nature.
6. What is Experiment ? How does it differ from Observation ?
7. Explain : "Observation and experiment differ in degree, not in kind."
8. Write short notes on :
   (a) Natural experiment
   (b) Non-observation of instances
   (c) Non-observation of essential circumstances
   (d) Mal-observation.
9. What are the relative advantages of Observation over Experiment and of Experiment over Observation ?
10. Explain the following statements :
    (a) Observation is finding a fact and Experiment is making one.
    (b) Observation is natural but Experiment is artificial.
    (c) Observation is passive experience but Experiment is active experience.

5

Causation

The Concepts of 'Cause' and 'Effect'

'Cause' and 'Effect' are very primitive concepts. They are involved in our use of a large number of transitive verbs of the language like make, produce, influence, build, destroy, kill, cure, etc. The subject of such verbs is the cause, the predicate is the corresponding effect. Ram kills Ravana; 'Ram' is the cause and 'killing of Ravana'is the effect. Quinine cures malaria; 'Quinine' is the cause and 'cure from malaria' is the effect.

The layman's notion of cause is 'what makes a thing to happen' and his notion of effect is 'what is made to happen due to something'. This is known as the activity view of *causation.* This view is expressed in the definition of these words as given by Locke. According to him, "A cause is that which makes any other thing.........................begin to be, and an effect is that which had its beginning from some other thing".

The activity view of causation assumes the cause to be an agent having the power to produce the effect. As a strong man has the power to lift a heavy weight, similarly fire has the power to melt wax, water has the power to dissolve sugar, lullaby has the power to make a child sleep, advice has the power to change a criminal to a saint and so on.

This view is realised to be too very anthropomorphic and things are said to have causal characteristics rather than having any mysterious power. A causal characteristic of a thing is a charac-

teristic mode of behaviour in relation to other things. Thus causation is realised to be a relation existing between modes of behaviour or events. This is the view of causation which is generally held in scientific circle, though in advance sciences *FunctionalRelation* has taken the place of causal relation and there is a tendency to discard altogether the notion of cause in scientific discussions.

Whatever be the attitude today in advanced sciences towards the concept of cause, it has always played an important role in our day-to-day life and also in the field of science in its primary stages. So it is worthwhile to examine and analyse the concept in detail.

A cause, in the ordinary sense, is effective only in suitable circumstances and not in adverse circumstances. A burning matchstick can set fire to a piece of paper, not to a piece of iron, only if the piece of paper be dry, and strong wind be not blowing at the moment. These other *conditions* necessary for the effect to take place are distinguished from what is taken as the cause. This distinction between the cause and the conditions remains vague in the choice of cause of a layman. Out of all the conditions, sometimes one and sometimes another is taken as the cause and the remaining are taken as the conditions. When a student fails in an examination, he may take the system of valuation to be the cause of his failure, his parents may take the manner of teaching in the college to be the cause and the teachers may take the degree of intelligence of the student to be the cause. Usually, Whatever appears to be the most striking to a man among the conditions, is taken by him to be the cause. This cannot be accepted in science. So scientifically, condition is taken to be a necessary part of the cause and cause is taken to be the sum total of all the conditions taken together.

A condition,which must be fulfilled in order that the concerned effect takes place, is called a *necessary condition.* To get admission in the M. A. class, passing the B. A. or its equivalent examination is a necessary condition, willingness to pay the requisite fees is another necessary condition. But each of these or both taken together does

not constitute the sufficient condition,because in spite of these conditions being fulfilled still admission may not take place.A condition or a set of conditions, the fulfilment of which leads to the occurrence of the effect is called *sufficient condition.*

A sufficient condition may not be a necessary condition. For the death of a man,being shot through the heart is a sufficient condition, but not a necessary condition, since the death may occur without being shot through the heart. Drinking strong poison is also another sufficient condition but not a necessary condition.

Scientific cause is both the necessary as well as the sufficient condition of the effect.

Qualitative and Quantitative aspects of Cause

Scientifically, cause may be viewed qualitatively or quantitatively.

Qualitative Aspect

According to Carveth Read, qualitatively,cause is "the immediate,unconditional, invariable antecedent of the effect". Let us try to analyse the implication of this definition.

(a) Cause and Effect are relative terms.

In Nature various phenomena occur. According to the Law of Causation, every event has a cause. When we try to determine the cause of an event, the event is taken as an effect.But this event itself may be the cause of some other event. So the same event is effect in relation to its cause and cause in relation to its effect.'Flood' is the effect of 'heavy rains', but it is the cause of 'failure of crops' in villages near the banks of the river. 'Failure of crops' is the effect of 'flood', but it is the cause of the 'poverty of people in the locality'. No phenomenon is absolutely cause or effect.

(b) The cause is an antecedent of the Effect.

Succession or antecedent–consequent relation is involved in the very conception of causation. It is uniformity of succession

which leads to the idea of cause and effect. Of the two phenomena associated by the relation of succession, that which precedes is called the cause and that which succeeds is called the effect. So logically, the cause cannot follow the effect. Again, if two phenomena occur simultaneously, there is no reason why one of them be arbitrarily chosen and named as the cause leaving the other to be named as effect.

Some logicians object to this view by saying that cause and effect are relative terms. An event cannot be called cause until the effect occurs. So cause and effect are simultaneous events. Further, if cause precedes and is a past event when effect occurs, how can we relate an unexisting event with an existing event by causation ?

Mellone, in reply, says that cause and effect should not be thought to be separate events. The course of Nature is a continuous process. Cause and effect are distinct but not marked off from each other. Cause and effect are separated by a mathematical line having no breadth. On one side we have the cause, on the other, the effect.

(c) The cause is an invariable antecedent of the effect.

Every event has innumerable antecedents, e.g., A flood in the Ganga may be preceded by a cyclone in Japan, a revolution in France, and the death of a great man in U.S.A. But none of these can be considered as the cause of the flood. If we take any and every antecedent to be the cause of a phenomenon, we commit the fallacy of '*post hoc ergo propter hoc*' which means 'after this therefore, because of this'. A guest comes to the house and a patient in the house dies. The guest is not the cause of the death.

The antecedent may be variable or invariable. An antecedent is variable, if it sometimes precedes the effect and sometimes not. An antecedent is invariable if it always precedes the effect. The cause is an invariable antecedent, because without it the effect cannot occur.

(d) The cause is the unconditional invariable antecedent.

The cause is an invariable antecedent but an invariable antecedent is not necessarily the cause. A homeopath may invariably give

his medicines in 'sugar of milk'. But the 'sugar of milk' is in no way connected with the cure. Fire is an invariable antecedent of smoke, but it is not sufficient for the occurrence of smoke. Wet fuel is also necessary. So fire is only a part of the cause. It is a necessary condition. But a necessary condition is not the whole cause. It should also be sufficient for the effect to take place. An invariable antecedent, which is sufficient for the effect to occur without any other conditions is an unconditional antecedent. Such an unconditional invariable antecedent is the cause.

According to Hume, cause is merely the invariable antecedent of effect. Reid said that in that case Day would be the cause of Night and Night also be the cause of Day. Mill, therefore, says, "It is not enough that the sequence is invariable...... The sequence must be unconditional also". Bain says that the cause is "the sole sufficing circumstance whose presence makes the effect and whose absence arrests it".

(e) The cause is the immediate unconditional invariable antecedent.

The cause is self–sufficient for the occurrence of the effect. In that case, it is also immediate; because if sometime must elapse after the antecedent for the occurrence of the effect, then that is a condition and the antecedent is not unconditional. So unconditionality implies immediacy.

Sometimes a distinction is made between a Proximate, Immediate or Direct Cause and a Remote, Mediate or Predisposing Cause. X uniformly precedes Y and Y uniformly precedes Z. Y is Proximate or Immediate cause of Z, but X is a Remote or Pre-disposing cause of Z. Without X, Y could not have occurred and without Y, Z could not have occurred. So X is supposed to be responsible for the occurrence of Z. Lady Macbeth instigates Macbeth and Macbeth plunges a dagger into the heart of Duncan. Plunging of the dagger of Macbeth is the Proximate cause of the death of Duncan. But instigation of Lady Macbeth is the Remote cause. For some purpose, the Remote cause may be considered

more important than the Proximate cause. Remote cause is remotely connected with the effect and is not altogether an unconnected event. But scientifically, Proximate cause is *the cause*, if it is unconditional.

Quantitative Aspect

According to Carveth Read, quantitatively, cause is "equal to the effect."

By this it is meant that the quantity of matter and energy in the Cause is exactly equal to that in the Effect.

This characteristic of Causation follows from the 'Laws of Conservation of Matter and Energy'.

Law of Conservation of Matter states that the total quantity of matter in the universe is constant. Law of Conservation of Energy states that total quantity of energy in the universe is constant.

From these laws it is evident that the cause can be neither more nor less than the effect in respect of matter and energy, for in that case the total quantity will either decrease or increase in course of time.

We take some quantity of clay and make a statue out of it. The weight of clay and the weight of the statue will be the same. You rub your hand and spend some energy. The effect is heat on your palm. The energy spent is equal to the heat energy obtained.

So, quantitatively, the Cause is said to be equal to the Effect.

Positive and Negative Condition

Generally an important condition is taken by the layman to be the cause. From the scientific point of view it is not proper to identify the cause with a condition, howsoever important it may be. Bain explicitly states that the cause is "the entire aggregate of conditions or circumstances requisite to the effect." Mill says that the cause is "the sum total of all conditions positive and negative taken together."

Condition is defined as that which is relevant to the occurrence of the effect. According to Carveth Read, "Condition means any necessary factor of a cause". It may be either positive or negative. It is positive, when its presence is necessary for the occurrence of the effect. It is negative, when its absence is necessary for the occurrence of the effect.

A picture falls from the wall. In determining the cause of its fall, we note several antecedents relevant to this event.

(i) The door was violently slammed.

(ii) The string with which the picture was hung was weak.

(iii) The picture was heavy.

(iv) It had no other support than the weak string.

(v) Nobody was present in the room to catch hold of the picture to avoid its falling, and so on.

The first three antecedents are positive conditions. The last two antecedents are negative conditions. Carveth Read and Mill differ in their definitions of Negative Condition. Carveth Read says "....a negative condition is one that cannot be introduced without frustrating the effect". So according to him, 'support other than the weak string' and 'a person to catch hold of the picture' are negative conditions. These two conditions must be absent for the effect to take place. They "cannot be introduced without frustrating the effect". Mill, on the other hand, says that a negative condition is "the absence of a preventive cause". So according to him, 'absence of the support other than the weak string' and 'absence of a person to catch hold of the picture' are the negative conditions.

Obviously, the colour of the wall, the sound of the stereomusic, the number of the chairs in the room are irrelevant to the occurrence. They are neither positive nor negative conditions. They are not conditions at all.

Aristotle's view of Causation

According to Aristotle, every effect is the outcome of four kinds of causes, *viz.*, Material cause, Formal cause, Efficient cause and Final cause.

The material cause of a thing is the material of which it is made. Thus the material cause of a stone statue is stone, of a gold statue is gold and so on. The nature of the statue depends on the nature of this material. So the material must be taken as a cause of the statue.

The formal cause of a thing is the form or shape the thing takes when produced. Thus the formal cause of a statue may be the form of Lord Buddha or Christ or anything else. The effect is different when the forms are different though made of the same material. So the form must be taken as a cause of the statue.

The efficient cause of a thing is the energy or skill necessary to produce the effect. Sometimes the agent or the producer himself is taken as the efficient cause. The effect depends on the labour and efficiency of the producer. Two sculptors endowed with different skill and ability will produce two different kinds of statue, though both are made of stone in the form of Lord Buddha. So the efficiency and energy of the sculptor must be taken as a cause of the statue.

The final cause of a thing is the end or purpose for which the effect is brought about. Thus the purpose for which a statue is made may be to put it in a place of worship or in a park or on the top of a building for decoration and so on. This purpose is present in the form of an idea from the beginning and determines the effect. So the purpose must be also taken as a cause of the statue.

The Naiyayika view of Causation

According to Nyaya, every effect is the outcome of three kinds of causes, *viz.*, Samavāyi Kāraṇa or constitutive cause. Asamavāyi Kāraṇa or non- constitutive cause and Nimitta Kāraṇa or efficient cause. The Samavāyi Kāraṇa of a piece of cloth is the threads which constitute the cloth. The Asamavāyi Kāraṇa of the cloth is the union of the threads without which the cloth could not have been produced. Besides these, the weaver and his weaving implements are necessary for the production of the cloth. They are the Nimitta Kāraṇa or the efficient cause.

It may be noted that what are named as causes by Aristotle and the Naiyāyikas are not considered to be causes by the Modern Logicians, because none of them is sufficient for the occurrence of the effect in the absence of the others. Hence they are conditions, not causes.

Popular view of Causation

Popularly, an important condition is taken as the cause of a phenomenon. It is the most striking or the immediately preceding condition which is usually taken as the cause. Thus, for example, when we fall down, we say that the slippery ground is the cause. We do not take into account our carelessness or the gravitation of the Earth. When a student fails in the Examination, the cause is supposed to be 'unexpected and difficult questions'or 'stiff valuation'. Sometimes, even a negative condition is supposed to be the cause. Thus 'absence of the dog'is supposed to be the cause of theft.

The popular view of causation has its source in the practical end of the common man. He wants either to get rid of something undesirable or to obtain something desirable. His search for causes is determined by these ends.

Suppose, petty thefts are recurrent in a locality. The investigating police officer traces out the thief and takes him into custody. No theft cases are reported thereafter. The thief, therefore, is considered to be the cause of the cases of theft. But, obviously, the thief is only a necessary condition. The other necessary conditions, without which the theft would not have occurred, are the existence of things in the house worth stealing, keeping the doors and windows open or lightly bolted,the locality being left unguarded at the time when thefts occurred etc. These are ignored and the one necessary condition, which is obvious, striking or active is taken as the cause.

In order to obtain something desirable, the knowledge of one necessary condition and its fulfilment will not be of much help. A

set of necessary conditions that constitutes a sufficient condition must be fulfilled in order to achieve the end.

To keep our living room lighted at night, a set of necessary conditions, e.g., lamp, kerosene, wick, matchbox etc, which constitute a sufficient condition must be fulfilled. If any necessary condition of the set be not fulfilled, then we cannot get the desired result. So here a sufficient condition is taken as the cause.

The common man finds that there are alternative ways for achieving his end. In the above example, candle-sticks and lighter also will serve the purpose. Electrification of the room with all that is necessary for it is a much better way. So popularly there are alternative causes for the same effect and the common man may choose that one which is convenient to him.

Generally, Moving Power or the Agent, as distinguished from the Collocation or the Patient is supposed to be the Cause.

Moving Power or the Agent is the power or force or energy which moves or incities to action. It is the active agent which produces the change. Collocation or the Patient,on the other hand, is the arrangement of circumstances or the thing acted upon.

Fire melts a piece of wax. A dose of medicine cures a disease. Magnet attracts iron. A blow kills a rat. In these cases, fire, medicine,magnet and blow are the Moving Power or the Agents which are supposed to produce the effects, i.e., melting, curing, attracting and death by being active. Wax, human constitution, iron and the rat are the Collocations or the Patient which are relatively passive.

Though popularly, the Moving Power or the Agent alone is supposed to be the cause, scientifically both, the Moving Power and the Collocation, or both the Agent and the Patient are taken into consideration in determining the cause. Fire melts a piece of wax. The same fire could not have melted a piece of iron. So for the effect, 'melting' both fire and wax are responsible. Both are equally important conditions and, they together or more correctly, their peculiar characteristics constitute the cause. Similarly, the medicine

could cure the disease because of the peculiarity of the human constitution concerned. The same medicine does not become equally effective in all cases because of the difference in the constitution. Magnet attracts iron, not wood. The blow could kill a rat. It might not have killed an elephant. So the Collocation or the Patientcannot be ignored. It has an essential role to play in the concept of the Cause from the scientific point of view.

In fact, some logicians totally disapprove the distinction between the so called Agent and the so-called Patient, the so-called Moving Power and the so-called Collocation. Scientifically, both are the sources of energy and so the distinction between the two is only nominal. Mill says, "The distinction between agent and patient is merely verbal ; patients are always agents".

Scientific view of Causation

The concept of cause is full of difficulties and to give an all-agreed account of the scientific view of causation is not easy. We shall note here a few points which are accepted in general.

1. Causation is a relation between pairs of events.

We notice changes in the things of our experience and become interested in finding out how or why the changes take place. We discover that certain other events are uniformly and invariably necessary for the changes to take place. Thus we establish causal relations between pairs of events and expect to find the one, when the other is found.

This relation is discoverable by observations and experiments. So the knowledge of causation is *a posteriori*, i.e., gained after experience. It is not known *a priori*, i.e., before experience as to which events are connected with which other events.

Two events come to be causally connected because of some characteristic behaviour of the concerned things. Cold solidifies water and heat boils it. Water has always exhibited this characteristic mode of behaviour in relation to temperature. So changes in temperature and changes in water are made terms of causal relation.

In science, the activity view, i.e., the cause having the power to produce the effect is rejected, because science confines its studies to observable facts and phenomena and the mysterious power of the activity view is not observable.

2. Cause never occurs after the effect.

Causal relation holds between events occurring in time. So causal relation must have some temporal characteristics. Generally, cause is said to precede the effect. It is the immediately preceding event and is continuous with the effect. But sometimes the priority of the cause is contended. Events that occur in a duration of time, if related by way of causation, are likely to overlap. In the case of a shower of rain which is the effect of dark clouds and cold weather, the cause and effect are said to be overlapping. Further, there is no known time lapse in the case of gravitation. One side of a see-saw is pressed down at a particular moment and the other side goes up at the same moment. This is said to be a case of *simultaneous causation.*

In any case, however, the cause can never occur after the effect.

3. Cause is both the necessary and sufficient condition for the occurrence of the effect.

A necessary condition may not be sufficient and a sufficient condition may not be necessary for the occurrence of an event.

Oxygen is a necessary condition for flame. Let us use the symbol C for the condition and E for the effect. Here we can say :

If not C, then not E.
Or
If E, then C.

But we cannot say :

If C, then E.
Or
If not E, then not C.

Cutting off the head of an animal is sufficient condition for the death of an animal. Using the same symbols as above, we can say here.

If C, then E.

Or

If not E, then not C.

But we cannot say :

If not C, then not E.

Or

If E, then C.

Scientific cause is both necessary and sufficient condition of the effect. So we can assert all the above four propositions in this case.

Science is interested in establishing such causal connections that of cause and effect, one can be definitely inferred from the other. So in science, the same cause has always the same effect and the same effect has always the same cause. The relation is not only invariable, but also reciprocal.

4. Causation is not logical implication.

Causal laws are inductively derived from experience. Empirical evidence is the only justification in their support. So the above 'If C, then E' and 'If E, then C' propositions are only what have been found to be true in experience. But neither C nor E *logically* implies the other.

Logical implication also is expressed in the form 'If p, then q'. But the relation between p and q is completely different from causal relation.

'If the heart beat stops, the animal dies' expresses a causal relation. It has been found to be so in experience. We can, however, imagine a world where this does not happen. In that world, stoppage of heart beat might make the animal more energetic.

'If A is bigger than B, then B is smaller than A' expresses a logical implication. We cannot imagine how in any world, one thing being bigger than the other, the latter is not smaller than the former.

Causal relation depends on experience. Logical relation does not depend on experience; it depends on the meaning of the words used.

5. Causal relation states the connection between two kinds of events, and not just two individual events.

When it is said that heat causes water to boil, it is meant that at any time and place, if heat is applied to water,it boils. It has happened in the past and it will happen in future. We say that the same cause leads to the same effect.

Cause and Effect being events happen in time. At a particular time, the heat event (H_1) occurred and the boiling event (B_1) occurred. That time is gone for ever. At another time, the heat event (H_2) occurs and the boiling event (B_2) occurs and so on. Now H_1,H_2, H_3 etc. are not exactly the same events, nor are B_1, B_2, B_3, etc. But H_1, H_2, H_3 etc. belong to the same class of heat and so also B_1, B_2, B_3, etc. belong to the same class of boiling. Causal relation is asserted between these two kinds of events. It is in this sense that 'the same cause leads to the same effect'—assertion is made and we expect the occurrence of B_n when H_n occurs.

Relation of functional dependence

In the causal law 'heat boils water', there is no mention of what amount of heat is necessary for boiling water. If we say water at sea level pressure boils at 212°F, we are more exact. The attempt to be exact and precise in the field of science has led the scientists not only to consider the qualitative aspect of events but also to consider their quantitative aspect. This results in the formulation of laws as functional dependence of characteristics.

$2x$ or x^2 is said to be a function of the variable x; since its value depends on the value that x takes. For example, if x is 0, 2x is 0; if x

is 1, 2x is 2; If x is 2, 2x is 4 and so on. $(x + y)^2 = x^2 + y^2 + 2xy$ is a law of functional dependence in Algebra. $h^2 = p^2 + b^2$ is such a law in Geometry where h stands for hypotenuse, p stands for perpendicular and b stands for base of any triangle. In well-developed empirical sciences also such laws are formulated. Galileo's law of falling bodies is expressed as $S = \frac{1}{2}gt^2$, where S is distance travelled by a body, g is acceleration of 32 ft. per second, and t is time in seconds. Similarly, Einstein's law of mass-energy relationship is expressed as $E = mc^2$, where E is energy, m is mass and c is velocity of radiation. Such laws express a quantitative relation between characteristics and make no reference to the events that have the characteristics.

Law of Conservation of Energy and its implications

The law of conservation of Energy asserts that the total quantity of energy in the universe always remains the same.

Energy means capacity for doing work. It is not always exhibited. A young man may have the energy or the capacity to run ten miles without any break. An old man perhaps has not this capacity. He is said not to have adequate energy to do this work. But neither the young man nor the old man ordinarily exhibits this energy. The energy is unexhibited or dormant. The dormant energy in the young man is exhibited or becomes manifest when he joins a race.

It is supposed that all changes in Nature, all occurrence of effects, all work done etc. are nothing but transformation of one kind of energy into another.

A stick is thrown upwards and is caught in the branches of a tree. The kinetic energy, i. e., the energy of motion of the stick is transformed into the potential energy, i. e., the energy due to the position of the stick. The potential energy of the stick up in the tree is greater than its potential energy, when it is on the ground. When the stick is released from the branches, the potential energy is

transformed back into kinetic energy and the stick moves downwards till it reaches the ground. At every point of movement of the stick, the potential plus the kinetic energy is the same.

Energy may be of different kinds, e.g., mechanical, heat, light, sound, electrical, magnetic, chemical etc. When a work is done, one kind of energy changes into another. The cause and the effect are the different aspects of the same quantity of energy. So the cause is the effect concealed and the effect is the cause revealed. No energy is lost at any time; only some quantity of energy in one form is changed into another form and the effect occurs. A stone moving with some force strikes a wall. It seems that the energy is lost, but here the mechanical energy is changed into heat energy, sound energy etc. The total energy after the impact is equal to the mechanical energy which the stone strikes the wall.

It may be remarked that these illustrations though correct, the conceptions of mass and energy have undergone a complete change now-a-days by the introduction of the theory of relativity which holds that mass and energy are inter-related.

Plurality of Causes

Plurality of causes means that the same effect may occur due to different causes on different occasions. Mill explains the doctrine of Plurality of Causes thus : " It is not true that one effect must be connected with only one cause, or assemblage of conditions; that each phenomenon can be produced only in one way". Carveth Read says, "The same event may be due at different times to different antecedents". Fowler used the term 'Vicariousness of Causes' to express this idea.

Examples : The effect 'light' may be due to the sun or the moon or fire or electricity etc. The effect 'death' may take place because of a disease or an accident or poisoning etc. Cure of a disease may be the effect of Allopathy or Homoeopathy or Kaviraji treatment etc.

Plurality of Causes should be distinguished from Conjunction of Causes. In Plurality of Causes, A or B or C independently is the cause of the effect X. But in Conjunction of Causes, A+B+C together constitutes the cause of the effect X. In the former, A, B, C etc. independently lead to the effect X. Each is self sufficient condition for the effect. In the latter, A, B, C etc. separately are incapable of leading to the effect. They jointly cause the occurrence of the effect. Plurality of Causes should also be distinguished from Plurality of Conditions. In Plurality of Conditions we hold that each of A, B, C etc. is the combination of several necessary conditions, say a, b, c. So A = (a+b+c) which leads to the effect X. But Plurality of Causes holds that different combinations of necessary conditions, i.e., A = (a+b+c) or B = (x+y+z) or C =(m+n+o) can lead to the same effect X.

Criticism : The doctrine of Plurality of Causes is unacceptable from the scientific point of view. Its unsoundness may be realised by the following considerations :

(i) Scientifically, cause is not only the sufficient condition, but also the necessary condition. The layman, while determining the cause of a phenomenon includes in the sufficient condition more than what is necessary and thus comes to hold the view of Plurality of Causes. For example, to light a fire, what is necessary is a spark. For this sometimes we use matches, sometimes a cigarette lighter, sometimes an electric lighter and so on. All these, though different in themselves, provide only one and the same necessary condition, the spark.

Always there is something common in the so-called alternative causes A, B, C etc., which is the real cause and which is invariably present. We ignore it and notice only A, B, C etc. But science notices what is really necessary. So scientifically one effect must be due to only one cause and not due to different causes.

(ii) As the cause consists of many conditions, the effect also consists of many consequents. In Plurality of Causes we do not take

into consideration this fact. On the Cause side we do not take the trouble of finding out the common element in A, B, C etc. and on the Effect side we do not take into consideration the accompanying circumstances of X. But if we find out the common element of the so-called different causes, we find that one effect has only one cause. This is called generalising the cause. Thus the common element in the so-called different causes of death. i.e. disease, accident, poison etc. is 'stoppage of vital function'. This is the only cause of death in different cases. In the alternative, we may take into consideration the different side-effects of death in each case and find that death in one case is different from death in another case, though the common element 'Death' is present in all cases. Death by poison is different from death by accident or death by disease. This is called specialising the effect. In *post-mortem* examination, they take into consideration all circumstances and find in each case the only cause of that particular kind of death. We say that the sun, the moon, the fire etc. can give the effect light. But we ignore the fact that the sun can give only sun-light, never moon-light or fire-light. Similarly,the moon can give only moon-light, never any other kind of light and so on.

So Carveth Read says, "If we know the facts minutely enough it will be found that there will be only one cause (sum of conditions) for each effect (sum of co-effects)". Welton and Monahan remark, "If each effect of a certain kind were considered in all its particularity we should see that one particular effect is not produced by a plurality of causes but by one only." If we generalise the cause as we generalise the effect, or conversely, if we specify the effect as we specify the causes, there is no plurality of causes. The doctrine of Plurality of Causes appears plausible because we generalise the effect, while specifying the cause.

Conjunction of Causes and Intermixture of Effects

Though one effect is always produced by only one cause, sometimes several effects are combined together and we get a joint

effect. The joint effect is the result of intermixture of several effects and is thus the effect of a number of causes. In intermixture of effects the several effects are blended so as to produce the impression of a single effect. Thus Conjunction of Causes leads to intermixture of Effects.

A has the effect a.
B has the effect b.
C has the effect c.

....

∴ A + B + C jointly has the effects a +b + c = X.

Thus X becomes an intermixture of effects as a result of the conjunction of the causes A, B and C.

The doctrine of Conjunction of Causes is different from the doctrine of Plurality of Causes. In Conjunction of Causes A, B and C jointly leads to the effect X. But in Plurality of Causes of A, B and C each separately leads to the effect X. The doctrine of Conjunction of Causes is similar to the doctrine of Plurality of Conditions. The difference between them is that in Conjunction of Causes the effect is considered to be a complex phenomenon, whereas in Plurality of Conditions all the necessary conditions constitute one cause and its effect is considered to be a simple phenomenon.

Intermixture of Effects may be of two kinds :

(i) When the joint effect is of the same nature as the separate effects, it is called Homogeneous Intermixture of Effects. This kind of intermixture is illustrated in Physics.

Examples : The effect of one bag of rice is a weight of 50 kilograms.The joint effect of two similar bags of rice is a weight of 100 kilograms. The joint effect of two electric bulbs of 60 candle power each is 120 candle power of light. The joint effect of purchasing a shirt of Rs. 90/-and a pair of trousers of Rs 160/- is incurring an expenditure of Rs. 250/-.

(ii) When the joint effect is of a different nature from the separate effects, it is called Heterogeneous or Heteropathic Intermixture of Effects. This kind of intermixture is illustrated in Chemistry.

Examples : The separate effects of different items of food are proteins, carbohydrates, fats, mineral salts and vitamins. But when digested, the joint effect is blood, flesh, bone etc., which are of different nature from the separate effects. The joint effect of Hydrogen and Oxygen is water.

EXERCISE

1. Explain the concept of cause and effect.
2. Explain the scientific view of Causation.
3. How has Carveth Read defined Scientific Cause ? Explain clearly its qualitative aspect.
4. Explain the law of Conservation of Energy. How is it connected with the quantitative view of causation ?
5. What is a Condition ? Explain the statement that the scientific cause is the sum total of all the positive and negative conditions taken together.
6. Explain critically the view that the same effect may be produced by alternative causes.
7. Distinguish between Plurality of Causes and Conjunction of Causes. Are they scientifically tenable ?
8. What do you mean by Intermixture of Effects ? Explain with concrete examples different kinds of Intermixture of Effects.
9. Distinguish between :
   (a) Positive condition and Negative condition
   (b) Moving power and Collocation
   (c) Agent and Patient.
10. Explain with examples the distinction between the scientific and the popular view of causality.
11. Compare and contrast :
    (a) remote cause with proximate cause
    (b) potential energy with kinetic energy
    (c) the view of Carveth Read with the view of Mill on negative condition.
12. Name with reasons the sort of causality involved in the following :
    (a) Absence of proper treatment is the cause of his death.
    (b) Inattentiveness in his class in school days is the cause of his poverty in old age.
    (c) Recommendation from a Minister is the cause of his being appointed as a lecturer.
    (d) Steel is the cause of the sword.
    (e) Intoxication is the effect of either wine or hemp or opium or some other narcotics

6

Hypothesis

Nature of Hypothesis

In our everyday life there are many facts of experience, which we wish to explain. We intend to know their causes. But very often the causes are not easily discovered. When the cause of a phenomenon is not known,we provisionally suppose something to be the cause so that further investigation may be made. If we find evidence in support of our supposed cause,i.e.,if the supposed cause is proved to be the real cause, the fact has been explained. But if the evidence runs contrary to our supposition, we discard it; suppose something else to be the cause, and we proceed to see whether it can be proved to be the cause of the phenomenon or not. The provisional supposition with regard to an unknown cause is called a Hypothesis. It is a probable cause, which when proved, is accepted as the real cause.

Mill defines Hypothesis as follows :

"An Hypothesis is any supposition which we make (either without actual evidence or on evidence avowedly insufficient) in order to endeavour to deduce from it conclusions in accordance with facts which are known to be real under the idea that if the conclusions to which the hypothesis leads, are known truths, the hypothesis itself either must be, or at least is likely to be true."

Coffey defines hypothesis as "an attempt at explanation; a provisional supposition made in order to explain scientifically some fact or phenomenon."

We may note the following points about Hypothesis :

(i) When the cause of a phenomenon is obvious, there is no need to frame any hypothesis. The brother pinches the baby and the baby cries. The cause of crying is obvious. There is no need to frame any hypothesis here.

(ii) When the cause is unknown, we make a provisional supposition, i.e, we frame a hypothesis. The baby was lying all alone but suddenly starts crying. We frame a hypothesis in this case : perhaps, some insect has bitten him. Do we have sufficient evidence for this supposition ? Perhaps not; but we must begin with a probable cause. We deduce some conclusion from this. If some insect has bitten, it may be still there on the body of the baby or in the bed. We search for the insect. If we find one, the hypothesis is likely to be true. We remove the insect and rub the part of the body; the baby stops crying. The hypothesis is verified and found to be true. If no insect is discovered, perhaps there is some other cause. We discard the former hypothesis for the time being and frame another hypothesis. Perhaps, he is hungry and so on.

Thus the hypothesis involves deduction and verification.

Logical form of the Hypothesis

Let h_1, h_2, h_3, etc. stand for the Hypotheses; A, B, C etc.stand for the consequences that necessarily follow from the hypotheses and E stands for the event to be explained.

If E, then either h_1 or h_2 or h_3 or h_4.
If h_1, then A ; but not -A ; $\therefore$ not- h_1.
If h_2, then B ; but not-B ; $\therefore$ not-h_2.
If h_3, then C ;but not-C ; $\therefore$ not-h_3.
If E, then either h_1 or h_2 or h_3 or h_4.
But not-h_1, not-h_2 and not h_3.
$\therefore$ If E, then h_4.
But E.
$\therefore$ h_4.

It may be mentioned that in our search for the cause of an event, e.g., the crying of the baby, it is not possible to assert a proposition of the form 'If E, then either h_1 or h_2 or h_3 or h_4'. We are never sure that we have exhausted all possible hypotheses or probable causes of an event. So even if the deduced consequence of a hypothesis be true, the hypothesis cannot be said to be certainly true. To take it to be so is to commit the fallacy of affirming the consequent thus :

If h, then D.
D.
∴ h.

This argument is obviously fallacious. So all that we can say by verifying, i.e., finding a deduced consequent to be true that the hypothesis is so far confirmed and is likely to be true.

Further, when the deduced consequences of a hypothesis is not verified, i.e., the consequent turns out to be false, it is not always the case that the hypothesis is totally wrong. It may be amended in such a way that the originally deduced consequent is not implied. In the case of the crying of the baby, if the insect be a flying one, it does not follow that it would be found in the bed or body of the baby. So if the insect is not discovered,we cannot totally discard the insect-bite hypothesis in this case.

From the above discussion it is clear that in our search for the cause of an event, it is not proper either to hastily take a hypothesis as proved, or to hastily discard it as disproved.

Kinds of Hypothesis

A hypothesis is framed in order to discover the unknown cause of a phenomenon. But a scientific cause is always the sum of a number of conditions and in different circumstances our knowledge of them differs. There is no need to frame hypotheses regarding those parts of the cause which are already known. We frame a hypothesis regarding the unknown part of the cause. So it is natural

that different kinds of hypothesis are framed in different circumstances.

Carveth Read has mentioned three kinds of hypothesis. They are hypothesis concerning Agent, hypothesis concerning Collocation and hypothesis concerning Law.

In a theft case, if we frame a hypothesis in order to know as to who committed the crime, it will be a hypothesis concerning the agent. If the aim of our hypothesis is to discover the arrangement of circumstances which made it possible for the thief to commit the crime, it is a hypothesis concerning collocation. The hypothesis, concerning law is an attempt to know the way in which the thief acted under those circumstances. When Uranus deviated from its calculated orbit, the hypothesis asserting the existence of another planet, subsequently named Neptune, was framed. It was a hypothesis concerning agent. The geocentric hypothesis of Ptolemy and the heliocentric hypothesis of Copernicus are hypotheses concerning collocation. Newton's hypothesis regarding gravitation is a hypothesis concerning law.

Welton has mentioned only two kinds of hypotheses. They are hypothesis of Cause and hypothesis of Law.

Scientifically speaking, both agent and collocation constitute the cause. So Welton names all hypotheses concerning the agent and the collocation as hypotheses of cause and distinguishes them from the hypotheses of law. Further,the hypothesis of cause is said to be explanatory and the hypothesis of law is said to be descriptive. But such a classification of hypotheses is not generally accepted. It is true that the scientific cause includes both the agent and the collocation;but it is not proper to separate the agent from its operations. So the hypothesis of the law should have been included in the hypothesis of the cause. It is said that all hypotheses aim at explaining the cause of an effect. So they are all concerning the cause or are explanatory. If a part of the cause is already known, we frame hypotheses regarding the remaining part, so that the effect is

satisfactorily explained. Therefore, the separation of the manner of operation from the cause cannot be justified.

Stebbing has classified hypotheses from a new angle of vision. According to her, the aim of hypothesis is not always only to explain by discovering the cause of a phenomenon. She mentions three main kinds of hypotheses. They are explanatory, descriptive and analogical.

Explanatory hypotheses are framed in order to reconstruct in idea the occurrence of an event to explain it. Such facts are interpolated which might have been observed under suitable conditions if an observer would have been present when the event took place. The reconstruction of a crime in a court of law is an instance of this kind of hypothesis. Motives are not observable, but she opines that hypotheses regarding them are also explanatory. The Newtonian hypothesis regarding attraction, i.e., an unobservable force is also taken by her as an explanatory hypothesis.

The aim of descriptive hypothesis is not explanation, but description that serves the function of a model in order to understand some complicated fact. The hypothesis of the ether as a frictionless fluid and as an elastic solid is descriptive. The deseription by Rutherford Bohr of atom as planetary is also such a hypothesis. Ptolemy's hypothesis was perhaps framed in order to represent the planetary motion by a geometrical figure. This is also a descriptive hypothesis. The usefulness of such a hypothesis in scientific investigation is great, since though of provisional character, it indicates the direction in which further observation and experiment may usefully be made.

The descriptive hypothesis in many cases develops into an analogical hypothesis. An analogical hypothesis is one which interprets a new set of phenomena by the principles which interprets a different set because of the presence of similar formal properties in both the sets. Sound and light have similar formal properties. So by an analogical hypothesis, the wave like movement of sound is attributed to the movement of light. Maxwell recognised an analogy

between certain problems in the theory of gravitational attraction and certain problems in electrostatics. This led him to formulate an analogical hypothesis and he ultimately succeeded in achieving remarkable results in the fields of electrostatics, magnetism and current electricity.

Three other kinds of hypotheses have received technical names. We may note them here.

(i) Working Hypothesis

Generally hypotheses are framed in order to understand or explain phenomena. But sometimes they are required for guiding investigation and collecting relevant facts. In a field where we have little knowledge, we are required to frame a hypothesis in order to just start the investigation itself.

Suppose, a police officer runs after a culprit and arrives at a cross road. He finds no trace of the culprit and he has no knowledge of the locality. There is no reason why he should run by one road rather than the other. But he cannot simply stand there gaping. He has to pick up a course to carry on his work with the supposition that the culprit, perhaps, has followed that course. This is a working hypothesis.

When the nature of electricity was unknown, scientists began investigation with the supposition that it was a fluid. It was a working hypothesis.

Thus, working hypotheses are advanced solely for the purpose of conducting investigations and are substituted by better hypotheses, when the nature of the phenomenon under investigation is understood.

(ii) Ad hoc Hypothesis

Sometimes some discrepancies are noticed in the working of a law or theory, which otherwise is convincingly well-established. If the law is to be retained, it is necessary to explain how the discrepancies occur in spite of the law being true. This is done by framing an ad hoc hypothesis.

The orbit of Uranus was determined in accordance with the law of gravitation. But deviation was noticed in the calculated path. The law of gravitation was very well-established and worked satisfactorily in other cases of its application. So an ad hoc hypothesis was framed that the deviation noticed was due to the attraction of some undiscovered planet. Subsequently, the planet was discovered with the help of a powerful microscope and thus the doubt regarding the efficacy of the law of gravitation was dispelled.

An ad hoc hypothesis is introduced in order to explain a single fact or set of facts. It has no further explanatory power. If it is confirmed,the purpose for which it was framed is served and the original law or theory is retained. But if it is disconfirmed or refuted, then the original law is either modified suitably or discarded completely.

(iii) Non-instantial Hypothesis

Non-instantial Hypotheses are those hypotheses which are framed at a later stage in the development of a science for the purpose of introducing order into the generalisations established in the science. It systematises the knowledge gained in the science by inter-relating a set of laws and showing that they are deducible from a more comprehensive theory.

Maxwell's Electromagnetic theory of light is an example of Non-instantial hypothesis. This theory has established that radio-waves, radar-waves, infra-red radiations, visible light radiations, ultra-violet radiations, X-rays, gamma rays etc. have essentially an identical nature.

Newton's law of universal gravitation and Einstein's theory of relativity are other examples of Non-instantial Hypothesis.

Such hypotheses are only indirectly verified, since they lack directly verifiable instances.

Place of Hypothesis in Scientific Enquiry

There is difference of opinion among scholars with regard to the importance of hypothesis in scientific enquiry.

Bacon condemns the process of framing hypothesis. He was against all kinds of prejudices, or 'idols'. He gave the utmost stress on accurate observation and experiment without having any preconceived notions. His method was 'examining Nature' not 'anticipating Nature' to conquer her. So he disapproves observation under the guidance of a hypothesis.

But it may be pointed out that Bacon himself agreed that undirected experience is insufficient in scientific investigation. Experimentation without a plan is groping in the dark. Methodical experimentation alone, not chance observation, is worthy of confidence.

Nature is vast and it is hypothesis alone which can suggest a direction,supply a plan and recommend a method. It should not be forgotten, however,that a hypothesis is only a probable cause, which must be vigorously proved or be discarded without ado.

Newton remarked, *"Hypotheses non fingo"*, i.e., I do not frame hypotheses. But Newton himself framed the famous hypothesis of gravitation. So it seems that he was not against a scientific hypothesis. He was only against the wild guess of the layman by which only time and energy are wasted in fruitless enquiries.

Mill does not disregard the importance of hypothesis in scientific enquiry. He, however, takes it as a mere supposition "either without actual evidence, or on evidence avowedly insufficient". It may be pointed out that scientific hypothesis is not a supposition without evidence. Further, the main concern of induction according to him is proof and so hypothesis has only a subsidiary place. He thinks that Inductive generalisations or laws of sciences can be established with the help of his experimental methods employed directly on facts of observation, though ordinarily a hypothesis is framed before the causal connection is proved.

Whewell, however, attaches very great importance to hypothesis. Induction, according to him, is concerned with discovery rather than proof. Discovery of a scientific law depends upon a

stroke of insight leading to a right hypothesis. Thorough acquintance with the subject-matter coupled with constructive imagination enables one to frame important hypotheses leading to great discoveries. Great geniuses also fail to frame the right hypothesis at once. Kepler had to reject nineteen hypotheses before the right one regarding the motion of planets was framed.

Most logicians consider the framing of a hypothesis to be a necessary step in scientific enquiry in order to establish an Inductive Law, and every scientist takes the utmost care and caution in formulating his hypothesis, since his observation, experimentation and mode of verification depend on it.

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Hypothesis, Theory and Law

The term 'Hypothesis' is used for a supposition when it is not yet conclusively proved. When proved and generalised, the hypothesis is called a 'theory'. The hypothesis of Darwin which has been satisfactorily proved, and can be generalised is called the theory of Evolution. In course of time when the theory becomes so well-established that it is taken for granted and becomes the source of other theories, it is termed as a 'law'. Thus the theory of Newton regarding gravitation is called 'The law of gravitation'. A law is raised to the rank of a scientifically established 'Fact' when there is absolutely no doubt regarding its truth and certainty. It is as good as facts of observation. The 'revolution of the Earth around the Sun' is a scientifically established fact now just like the existence of a table or the growth of a tree. The difference between a perceptual fact and a scientifically established fact is that the former is known by perception while the latter is known by scientific proof.

We may note here the relation between Hypothesis and Induction. Induction is sometimes taken as a process and sometimes as a product. When it is taken as a process, hypothesis is its starting point. When it is taken as a product, hypothesis is its first stage.

The hypothesis is taken to be the starting point of the Inductive procedure, because even the preliminary observation for inductive generalisation should not be vague and unguided. A provisional

supposition in the form of a hypothesis limits the field of observation, guides investigation and makes elimination possible.

The hypothesis is taken to be the first stage of Inductive generalisation considered as a product, because it is the provisional supposition, which, when adequately verified with modifications, if any, ultimately becomes the Inductive law.

Conditions of Legitimate Hypothesis

Hypothesis is a provisional supposition. But any and every supposition is not considered to be a proper hypothesis in science. To be a proper or legitimate hypothesis in science, every supposition must satisfy certain conditions. They are the following :

(i) The hypothesis should not be self-contradictory or absurd.

Self contradictory and absurd phenomena are not admitted in science. So for explaining facts we should not entertain suppositions which are self-contradictory or absurd in nature. If a magician by the wave of his magic wand makes the disappearance of a man possible, we should not suppose that the man is both visible and invisible or that the magician hides the man in his coat-pocket.

It should be pointed out, however, that what appears absurd to the layman may not be so to the scientist; what appears absurd at one age may not appear so at a later age. It was thought absurd to entertain the supposition that man can reach the moon, but now the supposition far from being absurd has been found to be true.

(ii) The hypothesis should not be vague but should be definite.

A hypothesis is framed in order to explain some phenomena. If it be vague and not definite, it does not explain the phenomena.

Further, no deduction from a vague supposition is possible and so it will remain unverified. Thus a vague hypothesis is useless in scientific investigation. In a theft case, if we remain satisfied with the supposition that somebody has committed it, no further investigation is possible, but if we suppose that one of the servants has committed it, it has narrowed our field of observation but is still not definite. If we suspect that a particular servant might have com-

mitted the theft, it is definite and we can verify the hypothesis which may turn out to be either true or false.

(iii) The hypothesis should not ordinarily be in conflict with the established truths.

In ordinary life and in science we take certain laws to be so well–established that they are taken for granted to be true and no doubt is entertained. If the hypothesis runs contrary to such well–established truths, the possibility is that the hypothesis is wrong. If the hypothesis is in harmony with such truths, it has the possibility of being proved as true.

The law of gravitation is an established truth and if a hypothesis contradicts this law, ordinarily we should reject it. A ball thrown to the air must come back to the ground. If it does not come back; we should not suppose that it is hanging in the air, and gravitation does not act on it.

It should be noted, however, that certain truths were supposed to be beyond all doubts, but hypotheses running contrary to them have been framed and they have been proved to be true. Many important discoveries in science are of this nature. The geocentric theory, i.e., the Earth is at the centre and the heavenly bodies are revolving round it, was supposed in earlier days to be well–established. But the heliocentric hypothesis of Copernicus, i.e., the Sun is at the centre and the Planets are revolving round it was framed, though it ran contrary to the then well–established geocentric hypothesis. Now the heliocentric hypothesis has been proved to be true. Newtonian concept of mass was accepted as 'truth beyond all doubts', but Einstein framed a hypothesis changing it radically and now Einstein is supposed to be correct.

So while framing a hypothesis we should consider whether the evidences in support of it are important and numerous enough to justify us in contradicting even an established law. In this case, the hypothesis should be capable of explaining facts in a better way than the law contradicted.

(iv) The hypothesis should be verifiable.

A hypothesis is a mere supposition, unless verified, it cannot be claimed to be either true or false. So verifiability or testability is an important condition of legitimate hypothesis.

A scientific hypothesis is framed in order to deduce conclusions from it and verify them with facts of observation. So if a hypothesis, by its very nature, is unverifiable, it is useless in science. The aim of framing a scientific hypothesis is to raise it to the rank of 'law' or 'fact' which is useful in life and in the field of science. But an unverifiable hypothesis cannot proceed a step beyond its mere formation.

To explain the great achievement of a mere boy in the field of philosophy, if we frame the hypothesis that in his previous life, he was a great philosopher, we cannot verify the hypothesis. Similarly, to justify the moral principle, if we frame the hypothesis that a dishonest rich man will go to hell after his death, we cannot verify it. Such hypotheses are not entertained in science.

(v) The hypothesis should be based on '*Vera Causa*'or real cause.

Though superstitious people believe in the existence of supernatural beings and take them as causes for explaining natural phenomena, scientifically natural phenomena are explained only with the help of natural causes. Newton says, "Only *Verae Causae* are to be admitted in explanation of phenomena". *Vera causa* means real cause. Perceivable facts or scientifically established facts are *verae causae* or real causes. Besides perceivable agents some other agents like gravitation are also taken as *vera causa*, because though they cannot be perceived, their existence can be proved scientifically. Such scientifically established phenomena are called 'Representative Fictions' by Bain.

Proof of Hypothesis

A legitimate hypothesis is of greater value than a working hypothesis. Working hypotheses do not satisfy all the conditions of legitimate hypothesis. They are admittedly inadequate. But when to explain a phenomenon it becomes impossible to frame a legitimate

hypothesis, we begin with a working hypothesis to use it as a guide for investigation. It is discarded or modified when evidence is available for a satisfactory legitimate hypothesis.

It should be remembered, however, that a legitimate hypothesis also is a provisional supposition. It needs to be proved to become a theory or a law. Hypothesis is a probable cause. To consider it to be the real cause proofs are necessary.

'Proof', however, does not mean here deducing the hypothesis from some axiomatic principles. It consists in showing that there is sufficient evidence to take the hypothesis to be correct; that it is the only hypothesis to explain relevant facts satisfactorily and that there is little possibility of its being refuted. So some logicians prefer the use of the term 'establishment' or 'corroboration' to the term 'proof' in this case. There is no objection to the use of the term 'proof' provided we remember the sense in which it is used here.

The following points are taken into consideration in the proof of a hypothesis :

(i) Verification

Verification of a hypothesis consists in an appeal to relevant facts. It may be either direct or indirect. Direct verification may be done either by Observation or by Experiment.

When the planet Uranus was found to be deviating from its calculated path, a hypothesis was framed that it was due to the presence of another planet not known till then. This hypothesis was verified by observation directly and realised to be true when an unknown planet was found to exist at the expected region. This was discovered with a powerful telescope and was named Neptune.

When Oxygen obtained from the atmosphere was found to be heavier than Oxygen derived from water, a hypothesis was framed that Oxygen obtained from the atmosphere contains some other gas. By scientific methods pure Oxygen was eliminated from the so-called Oxygen obtained from the atmosphere. The remaining gas was named Argon. The hypothesis was thus verified to be true by experiment.

Indirect verification may be done either by deduction or by accumulation of consistent facts.

Indirect verification by deduction consists in deducing conclusions from the hypothesis and verification of these conclusions by an appeal to facts of experience. If these conclusions are found to be true, the hypothesis itself is said to be verified indirectly.

'Black rust' is a disease of corns especially of wheat. A hypothesis is framed that some micro–organisms present in the air attack the seeds and are responsible for the disease. Microscopes, however, fail to detect the presence of such organisms in the seeds. It is, therefore, deduced that if they be the cause of this disease, seeds kept in air–tight bottles immediately after harvest will produce plants free from the disease. This conclusion has been proved to be true. So the hypothesis is taken to be indirectly verified. Non-instantial hypotheses are verified only indirectly, since direct verification is not possible in these cases.

Indirect verification is also made by accumulation of relevant facts. The cause of the 'curling disease' of the tomato, potato and tobacco leaves has not yet been found. Modern biologists, however, believe that some infinitesimal organisms in the atmosphere are responsible for the disease. The plants cannot be kept in air-tight containers to verify the hypothesis,for in that case the plants would die. So relevant facts in support of the hypothesis are being accumulated. The hypothesis will be taken as indirectly verified if sufficient number of such facts be accumulated. The Freudian theory that our conscious states are the effects of the unconscious can only be verified by accumulation of consistent facts.

(ii) Adequacy

The hypothesis should be adequate enough to explain all the facts connected with the phenomenon. Of two rival hypotheses,the one which explains more facts connected with the phenomenon is the more acceptable.

Both Ptolemaic and Copernican hypotheses regarding the movement of heavenly bodies could explain facts equally well. But it was found that Copernican hypothesis explains 'aberration of light' while Ptolemaic hypothesis fails to do so. So the Copernican hypothesis is accepted as true. The fact, *viz.*, 'aberration of light' which proves that one of the two hypotheses is more acceptable, is called a 'crucial instance'. When a crucial instance is found by experiment, it is called *'experimentum crucis'*.

Galileo conducted an *'experimentum crucis'* by letting fall cannon balls of different weights from the top of the inclined tower at Pisa. Thus the hypothesis that the velocity of falling bodies does not depend on their weight was proved to be true against its rival hypothesis that the velocity of falling bodies depends on their weight.

(iii) Consilience of Induction

'Consilience of Induction' is the name given by Whewell to the property of the hypothesis that explains not only the phenomenon for which it is framed but also many other facts. The theory of gravitation explains not only the falling bodies on the Earth but also the movement of the planets and the tides. So it is accepted as a correct hypothesis.

Indirect evidence is considered to be an important factor in establishing a hypothesis. If it is shown that the proposed hypothesis is similar to other hypotheses that have been established independently, then it gets indirect support from those hypotheses, and is taken as well corroborated and established.

(iv) Prediction

When by taking the hypothesis as true we make predictions and the predictions come true, then the hypothesis is taken as firmly established.

Meteorologists predict regarding the weather. Doctors predict regarding the course of a disease. Astronomers predict regarding

the occurrence of an eclipse or appearance of a comet. If the predictions come true, the hypotheses, on the strength of which the predictions are made, are taken to be correct. True predictions show that the hypothesis not only explains the present and past phenomena, but also explains the future phenomena equally well.

EXERCISE

1. Define hypothesis. What is its nature ?
2. What are the different forms of hypothesis ? Give concrete examples to explain each form.
3. Determine the value of hypothesis in scientific investigation.
4. How is hypothesis related to Induction ?
5. How are hypothesis, theory, law and fact related ? Explain with concrete examples.
6. State and explain the conditions of a legitimate hypothesis.
7. Explain what constitutes the proof of a hypothesis.
8. Write short notes on :
   (a) Working hypothesis
   (b) Ad hoc hypothesis
   (c) Non-instantial hypothesis
   (d) Scientifically established facts.
9. Explain with suitable examples :
   (a) *Vera causa*
   (b) *Experimentum Crucis*
   (c) Analogical hypothesis
   (d) Consilience of Induction.
10. You return from the College and discover that the transistor set which was out of order is missing. What hypotheses would you frame and how would you test them to find out the cause of its disappearance ?

7

The Experimental Methods of Mill

Importance of Experimental Methods in Primary Induction

Primary induction establishes the material truth of general real propositions. For this, observation of facts, analysis of them and examination of their mutual relation are necessary. If two facts are known to be causally connected, their relation can be expressed by a general real proposition, which will have a very high degree of probability to be materially true. So discovery of causal relations is considered to be an important factor in establishing general real propositions.

The Experimental methods are the methods or procedures suggested by Mill with the aim to establish causal relations between the two members of pairs of phenomena. He has formulated five different ways of establishing a causal relation. They are : Method of Agreement, Method of Difference, Method of Concomitant Variations, Joint Method and Method of Residues. Different methods have been suggested in order to suit to the different circumstances under which we are called upon to establish the causal connection. In a particular case one method may be more useful than the others. But a causal connection established by more than one method is definitely more reliable than that established by one method only, because each method has its own defects.

Mill makes very high claims for his Experimental methods but other logicians have pointed out a number of difficulties in the applicability of the methods. The main among these objections are :

(i) Nature is highly complex and not analysable into simple factors to suit to the requirements of the methods, (ii) The methods cannot eradicate the difficulties arising out of Plurality of Causes, (iii) Cases of Intermixture of Effects cannot be dealt satisfactorily by the methods, (iv) The Experimental methods are called inductive methods but they are not at all inductive. They are really deductive in character, because the principles on which the methods are based are deductions from the Law of Causation and the definition of cause.

Principles of Elimination and their relation with Experimental Methods

Discovery of causal relation is not an easy affair. Natural events are complex and complicated. Again, though events are observable, their relations are not observable. There are no distinct events in Nature. In the flow of natural events, we draw imaginary lines and treat events as distinct. No natural event can be more or less important than any other. But some of them are considered to be important and relevant whereas others are discarded as unimportant and irrelevant only from the stand-point of the purpose with which we start observation. The cause of an event must precede the occurrence of the event, but out of the innumerable preceding phenomena, it is difficult to ascertain which one or more of them are connected by way of causation with the event. So the process of searching for the cause of an event, begins by elimination of irrelevant phenomena, so that the field of relevance be narrowed and ultimately the cause can be discovered.

Principles of Elimination are the rules which enable us to eliminate the irrelevant phenomena and consequently to guess a probable cause. They are deducible from the definition of Cause. Qualitatively cause is defined to be the invariable unconditional immediate antecedent and quantitatively it is taken as equal to the effect. From this the following three principles of elimination are deduced.

1. Whatever antecedent can be left out without prejudice to the effect can be no part of the cause.

2. When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or a part of the cause.

3. An antecedent and a consequent rising and falling together in numerical concomitance are to be held as cause and effect.

While searching for the cause of Malarial fever, by applying the first principle of elimination we can know that unhealthy habits, weak constitution, old age etc. are not relevant to the cause of Malaria, since people suffer from it even if they do not have these. By applying the second principle of elimination we can know that insect-bite may be either the cause or a part of the cause, since children do not suffer from Malarial provided insect-biting is carefully avoided. By applying the third principle of elimination we may guess that mosquito bite is the cause of Malaria because Malaria cases are more numerous in mosquito-infected areas than in other places.

It may be noted that the principles of Elimination do not prove any phenomenon to be definitely the cause of an event. Their utility lies in creating suspicion in the mind of the investigator that certain phenomena are likely to be the cause.

Of the five Experimental Methods, the Method of Agreement makes use of the first principle of elimination; the Method of Difference makes use of the second principle and the Method of Concomitant Variations makes use of the third principle. The Joint Method, being a modification, makes use of either or both the first and the second principles. Similarly, the Method of Residues, being a variation of the Method of Difference, makes use of the second principle. Joseph, however, is of opinion that the Method of Residues is based on the following principle of elimination, which also can be deduced from the definition of cause. The principle is :

"Nothing is the cause of a phenomenon which is known to be the cause of a different phenomenon".

07 The Method of Agreement ×

Mill's Canon : "If two or more instances of the phenomenon under investigation have only one circumstance in common, the circumstance in which alone all the instances agree is the cause (or effect) of the given phenomenon".

Symbolical example

ABC are followed by abc.
ADE are followed by ade.
AFG are followed by afg.
∴ A is the cause of a
or a is the effect of A.

Concrete examples

(i) Many instances of Malarial fever are found to have only one circumstance in common, i.e., the bite of anopheles. In other circumstances, viz., age, sex, nationality, complexion, profession etc, the individuals suffering from Malaria differ. Bite of anopheles is the common antecedent of the common consequent, i. e., suffering from Malaria. So the common circumstance, viz.,bite of anopheles, is the cause of Malarial fever.

(ii) Many instances of Malarial fever are found to have been cured by taking quinine. Cure from the disease is the common consequent of the common antecedent, i. e., taking of quinine. So cure from Malaria is the efffect of taking quinine.

Principle of Elimination

The Method of Agreement is based on the principle : "Whatever antecedent can be left out without prejudice to the effect can be no part of the cause". In the symbolical example, D, E, F, G have been excluded in the first instance, but still the phenomenon 'a' occurs. So they cannot be the cause of 'a'. Similarly B, C have been excluded in the second instance, but still the

phenomenon 'a' occurs. So they are not causally connected with 'a'. From the antecedent side all circumstances except A can be excluded without prejudice to the phenomenon 'a'. So A which is invariably present must have been the cause of 'a', since 'a' must have a cause.

Characteristics

(i) The Method of Agreement is said to be the Method of Single Agreement.

It is necessary for this method that there should be agreement only in one circumstance and in every other circumstance the instances should differ. If the instances agree on a number of circumstances, it will be difficult by this method to ascertain which one of them is the cause. The singleness of the agreement generates our belief in the causal connection. So this method is called by Mellone and Coffey 'the Method of Single Agreement'.

(ii) The Method of Agreement is said to be mainly a Method of Observation.

The instances of this method may be collected by observation. The instances are not of any special kind needing experiment. If we are required to find out the cause of a phenomenon, we collect several instances where the phenomenon occurs. We examine the antecedents and if a common circumstance is noticed, we suppose it to be the cause of the phenomenon. If we are required to find out the effect of a phenomenon, we examine the consequents of the instances having the phenomenon. If a common circumstance is noticed, we suppose it to be the effect of the phenomenon.

It should be pointed out, however, that there is no bar in collecting instances for this method by experiment. If the instances are suitable, it is immaterial whether they are collected by observation or by experiment. It is called a method of Observation, because simple observation is competent enough to supply the required instances.

(iii) The Method of Agreement is said to be a Method of Discovery rather than a Method of Proof

The Method of Agreement does not prove a causal connection conclusively. We discover that wherever the phenomenon occurs, there is also the presence of another phenomenon. Discovery of this simultaneous occurrence of two phenomena leads to the belief that perhaps there exists a causal connection between them. Simultaneity of occurrence does not justify us in holding that a causal relation must exist. So this method is considered as a Method of Discovery and not as a Method of Proof

Advantages

(i) The Method of Agreement being a Method of Observation has a very wide range. It can be applied where experiment is not possible or not desirable.

(ii) Observation can pass from Cause to Effect and also from Effect to Cause. So by this method we can discover both the cause and the effect of a given phenomenon.

Disadvantages

(i) The method of Agreement cannot eradicate the difficulties arising out of Plurality of Causes.

Three different persons suffering from headache may take three kinds of pills, e.g., Anasin, Codopyrin and Saridon with water and get relief from pain. According to this method water which is common in the three instances is the cause of relief from pain. This is obviously wrong. Mill calls this to be the characteristic imperfection of the Method.

This defect can be avoided to some extent by multiplication of instances, because when a large number of instances are taken, some persons may be found to have taken the pills without water and thus water may be detected to be only an accidental factor.

(ii) In the Method of Agreement we are liable to commit the fallacy of Non-observation.

The Method collects instances by observation and there is always the possibility of hidden circumstances which are really responsible for the effect. A common circumstance discovered easily may not be necessarily essential to the effect. All the successful medical practitioners of a locality may have the habit of wearing European dresses, but it is merely an accidental feature. However, the method of Agreement may take note of such factors and may ignore essential characteristics like sincerity, sympathetic dealing with the patients, medical insight etc.

This difficulty can be avoided to some extent by careful observation and multiplication of instances; but in any case, by mere observation we can never be sure that all essential circumstances for the occurrence of the effect have exhaustively been noted.

(iii) By the Method of Agreement, we are unable to distinguish Causation from Co-existence.

By this Method, invariable relation between two phenomena is taken as an indication of causal relation between them. But two such phenomena may be the co-effects of the same cause. Thus lightning may be wrongly supposed to be the cause of thunder. Similarly, rise in temperature may be supposed to be the cause of headache.

(iv) By the Method of Agreement, we are unable to distinguish Cause from Condition.

The common antecedent may be a part of the cause but not the whole cause. Examining several recitals of excellent instrumental music to the accompaniment of '*Tablas*' we may come to the conclusion by this Method that accompaniment of '*Tablas*' is the sole cause of the excellence of the music. Here we mistake a condition to be the sole cause. Carveth Read, for this reason, modified the canon of the Method as given by Mill thus : "If two or more instances of a phenomenon under investigation have only one other circumstance (antecedent or consequent) in common, that circumstance is probably the cause (or an indispensable

condition) or the effect of the phenomenon, or is connected with it by causation".

(v) The Method of Agreement is incapable of dealing with cases of Intermixture of Effects.

This Method presumes that the different antecedents and consequents are distinguishable, e.g., A, B, C, are followed by a, b, c. But the effects may be combined into a joint one where the separate effects are indistinguishable. In such cases it is not possible to detect the effect of a particular antecedent.

(vi) The result of the Method of Agreement is only probable.

The probability increases as the number of instances increases. So a large number of instances only can give us highly probable conclusions. In any case, this method cannot give us the sort of conviction and reliability that is necessary in scientific investigation unless supplemented by other Methods.

The Method of Difference

Mill's canon—"If an instance in which the phenomenon under investigation occurs and an instance in which it does not occur have every circumstance in common save one, that one occurring only in the former; the circumstance in which alone the two instances differ is the effect, or the cause, or an indispensable part of the cause of the phenomenon".

Symbolical Examples

(i) ABC are followed by abc.
BC are followed by bc.
∴ A is the cause of a.

(ii) BC are followed by bc.
ABC are followed by abc.
∴ A is the cause of a.

Concrete Examples

(i) In a lighted room the furniture are visible at night. When the light is switched off, visibility is lost. So we conclude that light is the cause of human visibility.

(ii) A lady applies cocoanut oil everyday to her hair and it has a certain growth. The doctor advises her to mix a certain chemical in the oil and apply it to her hair. She does so and rapid growth of hair is noticed. So the chemical is the cause of the rapid growth of hair.

(iii) You sip your morning coffee and find that it does not taste well. You add a bit of sugar and it becomes tasteful. So sugar is an indispensable part of the cause of the taste of coffee.

Principle of Elimination

The Method of Difference is based on the principle : "When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or a part of the cause". In the first symbolical example, we eliminated A from the antecedent side and 'a' disappears. So A must have been the cause of 'a'.

In the second symbolical example A was absent in the first instance. It was introduced in the antecedent side and 'a' appears in the consequent side. So A is taken to be the cause of 'a'.

In the third concrete example sugar is an indispensable condition of the taste of coffee because the taste of coffee is different from the taste of only sugar.

Characteristics

(i) The Method of Difference is said to be the Method of Single Difference.

It is necessary for this Method that there should be two and only two instances. They are identical in every respect except that in the positive instance, besides the phenomenon under investigation one more circumstance occurs and in the negative instance, that circumstance does not occur. Thus here the singleness of the difference constitutes the ground of proof. Mellone and Coffey, therefore, call this Method the Method of Single Difference.

(ii) The Method of Difference is mainly a Method of Experiment.

The two instances required by the Method of Difference are of a special type. They should be identical in every respect except in one. It is difficult to assure ourselves that the two instances are similar in all but one respects, if we collect the instances by observation. There is always the possibility of the existence of hidden circumstances. But in experiment the object of observation is under our control and isolation is possible. We introduce something or eliminate something and note the effect. We may be sure that nothing extraneous has intervened. So we take the help of experiment for the purpose of collecting instances for this Method.

It should be pointed out, however, that we may and in fact very often do apply this Method to the cases of observation, though the result cannot be as certain as that when the instances are experimentally obtained. A man feels thirsty, drinks a glass of water and the thirst is quenched. Drinking of water is the cause of quenching of thirst. A little boy is playing with his toy. His sister snatches away the toy and he starts crying. Removal of the toy is supposed to be the cause of crying of the boy. But we may discover on enquiry that it is not the removal of the toy but the biting of an insect at the same moment which is really the cause of crying. So we cannot be sure of the result if the instances are collected by observation.

(iii) The Method of Difference is said to be a Method of Proof in cases of experimental observation.

The Method of Agreement does not prove a causal connection but merely suggests something to be the cause which may be entertained as a hypothesis and can be confirmed experimentally with the help of the Method of Difference. When strictly applied, the result of the Method of Difference is claimed to be certain with respect to at least the particular case under investigation. The causal relation between the antecedent and the consequent here is taken as proved, provided no generalisation is made from the case examined.

Advantages

(i) The Method of Difference requires only two instances, though of a special kind. So the trouble of collecting a large number of instances is avoided.

(ii) It is claimed that it can conclusively establish a causal relation, under ideal conditions.

(iii) When applied to cases of experiment, the result obtained by this method is reliable.

Disadvantages

(i) The Method of Difference cannot eradicate the difficulty arising out of the Plurality of Causes.

According to Mellone it proves *a* cause but not *the* cause. In a particular case, this method can conclusively prove that X is the cause of Y, but it does not prove that X is the only cause of Y. It is quite possible that in other cases something else may be proved to be the cause of Y. In order to prove that X is the only cause of Y, we have to take several instances where Y occurs and show that in every case X is the cause. But by doing so we are applying no longer the Method of Difference but the Joint Method of Agreement and Difference.

(ii) In the Method of Difference, we are liable to commit the fallacy of *post hoc ergo propter hoc*.

The fallacy means 'after this therefore due to this'. A comet appears and a great man dies. Superstitious people take the appearance of the comet to be the cause of death of the great man. With the help of other methods such a connection is proved to be wrong.

(iii) By the Method of Difference, we are unable to distinguish Cause from Condition.

Mill's canon itself states that the circumstance in which the two antecedents differ may be either the cause or an indispensable part of the cause, i.e., a condition. BC is followed by bc. But when A is

introduced and 'a' appears, A may not be independently competent enough to produce 'a'. The effect 'a' may be the result of the combination of A with BC. Addition of a bit of sugar brings about the right taste of coffee, but sugar alone is not the cause of the taste.

(iv) The method of Difference cannot proceed from Effect to Cause.

By experiment we can proceed from cause to effect, but not from effect to cause. So as a method of experiment, this Method cannot proceed from effect to cause.

(v) The Method of Difference is inapplicable in the case of permanent causes. The permanent causes, e.g., friction, gravitation on the surface of the Earth etc. cannot be totally eliminated. So this method is not applicable in such cases.

(vi) Ordinarily, the fulfilment of the requirements of the Mehod of Difference is difficult. The possibility of the influence of hidden agents is difficult to counteract. So the range of application is more limited than that of the other methods.

(vii) If any time should elapse between the introduction of the cause and the appearance of the effect, the Method cannot yield certain results. A man feels exhausted, takes an invigorating drug and after half an hour, gets refreshed. We cannot say that the drug is the cause of the man's feeling refreshed, because the rest of half an hour might contribute, even though a little, towards getting over the feeling of tiredness.

The Joint Method of Agreement and Difference

Mill's canon:—"If two or more instances in which the phenomenon occurs have only one circumstance in common, while two or more instances in which it does not occur have nothing in common save the absence of that circumstance, the circumstance in which alone the two sets of instances differ is the effect or the cause, or an indispensable part of the cause of the phenomenon".

Symbolical example

Positive set
ABC are followed by abc.
ACD are followed by acd.
ADE are followed by ade.
Negative set.
BCD are followed by bcd.
DEC are followed by dec.
EFD are followed by efd.
∴ A is the cause of a.

Concrete examples

(i) It is noticed that whenever a man takes coffee at night, he suffers from sleeplessness, but when he does not take coffee at night he does not suffer from sleeplessness; other circumstances during the days of suffering and the days of not suffering from sleeplessness remain almost the same. So we conclude that taking *coffee* at night is the cause of his suffering from sleeplessness.

(ii) It is said that whenever Napoleon personally conducted a battle, it was won; but whenever he was absent, the battle was lost. So it is concluded that the force of his personality was the cause of success in battles.

Principle of elimination

The Joint Method is a modification of the Method of Agreement as well as the Method of Difference. So the principles of Elimination of both these Methods are made use of in this Method. 'Whatever circumstance can be eliminated without affecting the phenomenon under investigation is no part of the cause'. In the positive set B, C, D, E have been eliminated in one instance or the other, but still 'a' occurs. Again, 'whatever cannot be eliminated without interfering with the phenomenon under investigation must be causally connected with it'. In the negative set whenever A has been eliminated 'a' has disappeared in spite of the presence of other circumstances. So A must be causally connected with 'a'.

Characteristics

(i) The Joint Method is not a primary method. It is considered to be a double application of the Method of Agreement, viz., agreement in presence in the positive set and agreement in absence in the negative set. It is, therefore, an improvement over the Method of Agreement. Fowler calls this Method 'the Double Method of Agreement' and Bain calls this method the 'Method of Double Agreement'.

The Joint Method is considered to be a modification of the Method of Difference as well, since in the Method of Difference, we take only two instances, one positive and the other negative, while in the Joint Method we take two such sets of instances. In one instance of the Method of Difference the phenomenon under investigation and another circumstance are present and in the other instance they are absent. Similarly, in the positive set of the Joint Method they are uniformly present and in the negative set, they are uniformly absent. Rigorous experiment is necessary for obtaining the right type of instances for the Method of Difference. But instances may be collected by observation for the purpose of the Joint Method. So in our everyday life we make use of the Joint Method wherever possible.

Mill calls this Method 'the Indirect Method of Difference', because the negative instances are obtained not directly by experiment but "indirectly, by showing what would be the result if experiment could be made."

(ii) The negative instances should be collected in such a manner that they should resemble the positive instances in every particular except the absence of the prospective cause and effect. All the circumstances present in the positive set besides the prospective cause are excluded in the negative set and shown to be unconnected with the phenomenon under investigation, as their presence does not produce the effect. Venn, therefore, calls this Method 'the Method of Exclusion'.

(iii) The Joint Method is considered to be a Method of Proof. The causal relation suggested by the Method of Agreement is confirmed by this Method, if the negative instances are exhaustive.

Advantages

(i) The Joint Method being a Method of Observation has a wide range of application. But the conclusion arrived at by this Method is more reliable than that by the method of Agreement, because it takes note of the negative instances.

(ii) The Joint Method is said to be free from the difficulties arising out of the plurality of causes, since all circumstances having any possibility of being the cause besides the common antecedent in the positive set are shown to be unconnected with the phenomenon under investigation in the negative set, because their presence does not produce it.

Disadvantages

(i) The Joint Method does not enable us to distinguish Causation from Co-existence.

Two phenomena may be present in several instances and may be absent in several similar instances, but still they may be the co-effects of the same cause. Lightning and thunder both are present in several cases of cloudy weather and both are absent in several such cases. But lightning is not the cause of thunder.

(ii) The Joint Method is not useful in cases of Intermixture of Effects.

For the purpose of this method, the different antecedents and the different consequents should be distinguishable; but when the consequents blend together into a complex effect, naturally we cannot apply the Joint Method.

(iii) The Joint Method does not enable us to distinguish cause from condition. It may be shown that salt is uniformly present in several dishes of palatable curries, but the same dishes become unpalatable when no salt is given. By this method we are liable to

conclude that salt alone is responsible for palatableness of the curries.

(iv) The Joint Method is inapplicable in case of permanent causes, since it is impossible to discover negative instances in such cases.

The Method of Concomitant Variations

Mill's canon —"Whatever phenomenon varies in any manner whenever another phenomenon varies in some particular manner, is either a cause or an effect of that phenomenon, or is connected with it through some fact of causation".

Symbolical examples

(i) A_1 BC are followed by a_1 bc.
A_2 BC are followed by a_2 bc.
A_3 BC are followed by a_3 bc.
∴ A is the cause of a.

(ii) A_1 BC are followed by a_1 bc.
A_2 DE are followed by a_2 de.
A_3 FG are followed by a_3 fg.
∴ A is the cause of a.

Concrete examples

(i) When heat increases, the mercury in the thermometer expands. So heat is the cause of the expansion of mercury.

(ii) When the price of a commodity increases, demand for it decreases. So price is causally connected with demand.

(iii) When the force with which a body is struck increases, speed with which the body moves increases. So force is the cause of the speed of movement of the body.

Principle of Elimination

The Method of Concomitant Variations is based on the principle : "An antecedent and a consequent rising and falling together in numerical concomittance are to be held as Cause and

Effect." Considered quantitatively the cause is equal to the effect. So any quantitative variation in cause leads to a corresponding variation in the effect.

In the first symbolical example, A_1 changes to A_2, A_3, and a_1 changes to a_2, a_3 in the different instances, while the accompanying circumstances BC, bc remain the same. In this form, the Method of Concomitant Variations is a modification of the Method of Difference, because the accompanying circumstances always remain the same in both the cases. The distinction between the two is that in the Method of Difference, 'A' and 'a' are wholly present in one instance and totally absent in the other; but in the Method of Concomitant Variations, 'A' and 'a' are partially present and partially absent in the instances. Like the Method of Difference, the Method of Concomitant Variations also collects the instances by experiment to satisfy the requirements of such an example.

In the second symbolical example, when 'A' and 'a' vary quantitatively, the accompanying circumstances change from instance to instance. In this form, the Method of Concomitant Variations is a modification of the Method of Agreement, because in both the cases the accompanying circumstances differ from instance to instance. The distinction between the two is that in the Method of Agreement, 'A' is wholly present in all the instances, but in the Method of Concomitant Variations, 'A' is present in varying degrees in the different instances. Observation is competent to supply the instances for this form of the Method of Concomitant Variations as well as for the Method of Agreement.

The concomitant variation of this Method may be either direct or inverse. In the third concrete example, the variation is direct, because the antecedent and the consequent, both increase or decrease together. In the second concrete example, the variation is inverse, since increase in the price decreases the demand and decrease in the price increases the demand. It may be remarked that cause and effect being equal quantitatively, the increase in one

cannot lead to the decrease in the other. They must vary directly. Here increase in the price may be said to be the cause of increase in the determination to do without the thing.

Characteristics

(i) The Method of Concomitant Variations is either a modification of the Method of Agreement or the Method of Difference according as the accompanying circumstances are different from instance to instance or remain constant. So it is not a primary method.

(ii) The Method of Concomitant Variations is dependent on the quantitative aspect of causation and can be represented graphically or in a tabular form. It is, therefore, called a Graphic Method or a Statistical Method.

(iii) It is said to be a Method of Discovery, because when two phenomena vary simultaneously, an intimate relationship between them probably causal, is suspected. Important discoveries of causal relationship are made in sciences like Sociology, Psychology etc. with the help of this method. Taking statistics and establishing correlations are important steps in scientific investigations. The relation between moon and tide and the relation between wine and crimes like murder, assault etc. were established by the Method of Concomitant Variations.

Advantages

(i) As a modification of the Method of Difference, when applied experimentally, it is considered to be a Method of Proof.

As such, the conclusion derived by this method becomes highly probable and quite reliable.

(ii) The Method of Concomitant Variations is applicable in the cases of Permanent Causes, e. g., heat, friction etc. which cannot be wholly eliminated. It is specially applied in such cases, because the Method of Difference demanding complete elimination is inapplicable here.

(iii) The Method of Concomitant Variations is useful in cases of Intermixture of Effects. Though the separate effects are blended into a complex effect, we may vary an antecedent and see whether corresponding variation takes place in the effect or not. If the variations are proportional, some sort of a causal relation is inferred. In the absence of any variation, the antecedent is considered merely accidental.

Disadvantages

(i) The Method of Concomitant Variations is not applicable beyond certain limits in many cases. Water contracts with the decrease of heat, but below 39.4° F it does not contract, rather it expands. Physical exercise increases muscular strength up to a certain limit, thereafter it deteriorates muscular strength. Intensity of sensation increases, when quantity of stimulus increases up to a certain limit, but it does not hold good beyond the limit.

(ii) The Method of Concomitant Variations is not applicable in cases of qualitative variations. The Method is applicable as long as we take a thing of the same quality varying in quantity. Thus we may apply the Method to heat and expansion of the volume of water till the boiling point is reached. But when water changes to steam, we can no longer consider it to be water of greater volume.

(iii) The Method of Concomitant Variations does not enable us to distinguish Causation from Co-existence. Two things varying concomitantly may nonetheless be co-effects of the same cause and not related as cause and effect. There is inverse variation between the lengths of day and night. When days become shorter and shorter, nights become longer and longer, but days and nights both are the co-effects of Earth's rotation round its axis in a specified period of time.

(iv) The Method of Concomitant Variations is not free from the difficulties of Plurality of Causes when it is a Method of Observation. In the second Symbolical example, the variation of a_1 to a_2 may be due to the introduction of DE instead of BC, and of a_2 to a_3 due to the introduction of FG instead of DE.

(v) The Method of Concomitant Variations does not enable us to distinguish Cause from Condition. When the variation between the antecedent and the consequent is not mathematical, the former is perhaps a condition and not the cause of the latter; e.g., suppose, when A_1 becomes A_2, a_1 becomes a_5 and when A_2 becomes A_3, a_5 becomes a_{17}; here, 'A' may be a part of the cause of 'a' but not the whole cause. The rapid increase in 'a' is perhaps due to some other hidden conditions. Cause and effect, being equal from the standpoint of quantity, are bound to vary proportionately.

The Method of Residues

Mill's canon —"Subduct from any given phenomenon such part as is known by previous induction to be the effect of certain antecedents and the residue of the phenomenon is the effect of the remaining antecedents".

Symbolical example

ABC are followed by abc.
BC are known to be the cause of bc.
∴ A is the cause of a.

Concrete examples

(i) The shop-keeper weighs the empty container. Then he pours oil into the container and weighs the container with oil. By deducting the weight of the empty container from the total weight, he determines the weight of the oil.

(ii) You buy three articles and pay Rs. 15. You know the prices of two of them to be Rs. 3 and Rs. 5. So the price of the third article is Rs. 7.

Principle of Elimination

Joseph states the principle of this Method thus: "Nothing is the cause of a phenomenon which is known to be the cause of a different phenomenon." In the symbolical example, we know by previous inductions that B and C are the causes of b and c. So they cannot be the cause of 'a'. Hence, something else must be responsible for the

'a' part of the total effect. If we find on the antecedent side 'A' to be unavoidably present, this 'A' must be the cause of 'a'.

Characteristics

(i) The Method of Residues is said to be a Method of Discovery rather than of Proof Mellone states that the Method is "a finger-post to the unexplained." He states the canon of the Method thus: "When any part of a complex phenomenon is still unexplained by the causes which have been assigned, a further cause for this remainder must be sought."

Argon was discovered by Rayleigh and Ramsay by this Method, when it was noticed that Nitrogen obtained from the atmosphere was heavier than Nitrogen obtained from chemical sources.

Adams and Verrier discovered Neptune by the application of this Method, when Uranus deviated from its calculated path.

(ii) The Method of Residues is applicable only when some progress in the knowledge of causation has already been made. When we already know the causes of some parts of the complex effect, we seek for the cause of the residual among the remaining antecedents.

(iii) The Method of Residues is said to be essentially a Method of Deduction. It is said that Observation and Experiment play a minor role, because they supply only some cases of the complex phenomenon with its antecedents. Then it is mainly by calculation or deduction that we arrive at the conclusion. It may be pointed out, however, that all the other Inductive Methods also make use of deduction in deducing conclusions from hypothesis and verifying them. The principles of elimination on which the Methods are based are nothing but deductions from the definition of cause. The description of the method of Residues as essentially a Method of Deduction may be justified on the ground that the Method of residues makes use of deduction more in comparison to the other Methods.

(iv) The Method of Residues is regarded as a special modification of the Method of Difference. Both the Methods take two

instances only, one of which contains the phenomenon under investigation and the other does not contain it. The distinction is that in the Method of Difference the negative instance is supplied by experiment or observation, but in the Method of Residues the negative instance is supplied by previous Inductions. The Method of Difference is considered to be a Method of Proof,but the Method of Residues is considered as a Method of Discovery.

Advantages

(i) The Method of Residues is useful in cases of complex effect.

(ii)The method of Residues is said to be capable of proving a causal relation if the data are collected by experiment. If ABC be the immediate, invariable and unconditional antecedents of abc and if BC be known to be the causes of bc, no amount of doubt can be entertained in holding A to be the cause of 'a'. 'It is by this process' says Herschel 'that science, in its present advanced state, is chiefly promoted'.

Disadvantages

(i) The Method of Residues is inapplicable in cases where previous knowledge of causal relation is lacking.

(ii) The Method of Residues is inapplicable where the complex effect is unanalysable.

Uses and Application of the Methods

All the Inductive Methods aim at proving causal relation between two phenomena. They do so by eliminating irrelevant circumstances. So Carveth Read remarks, "In the final analysis they are all reducible to one, namely Difference." According to him, the Method of Agreement is reducible to the Method of Difference, for we prove A to be the cause of 'a' because in different instances B, C, D, etc. are all excluded, but 'a' still appears. Some other logicians hold that the Method of Difference can be reduced to the Method of Agreement, because it is the agreement of BC in both the instances which proves A to be the cause of 'a'. But logicians in

general hold both the Method of Agreement and the Method of Difference to be fundamental, thouth the latter is considered to be better than the former, because it is supposed to prove a causal connection while the former only suggests such a connection. The other methods are nothing but modifications of these two fundamental methods.

It may be remarked, however, that the three other methods are not useless modifications of the two fundamental Methods, but have arisen out of the need to deal adequately with the different situations under which we are called upon to establish causal connection.

Though experiment is preferable to observation, all matters cannot be experimented upon. The Method of Difference may be the inductive method *par excellence* and may prove causal relation conclusively, but its requirements cannot be complied with satisfactorily by observation. So other methods are made use of in cases where observation is the only means of collecting data. The Method of Agreement and the Joint Method, which are essentially methods of observation, are most useful in such cases. We may, of course, make use of the other methods as well, if the circumstances permit. Where experiment is possible we prefer to use the Method of Difference. But even when experiment is possible, the Method of Difference cannot deal with cases involving permanent causes. In such cases the Method of Concomitant Variations as a modification of the Method of Difference is useful. Where experiment is not possible but permanent causes are involved, we apply the Method of Concomitant Variations as a modification of the Method of Observation.

The Method of Residues is most useful as a Method of Proof where experiment is possible and some causal relations have already been established between the phenomena involved. But it is useful as a Method of Discovery in cases where the data are collected by observation, and previous inductions have made some progress by

establishing causal connection. It appears that the requirements of the Method of Agreement can very easily be fulfilled, because it demands only collection of several instances of the phenomenon under investigation, but it only suggests a causal connection. The conclusion is merely probable. It is a method of Discovery. The Joint Method is a special device to prove the conclusions arrived at by the Method of Agreement. Further, the Joint Method is free from the difficulties arising out of the plurality of Causes, whereas, the Method of Agreement and even the Method of Difference cannot eradicate them.

Thus we see that each method is useful in its own sphere.

It may be observed, however, that every method has its own defects which can be, to a very great extent, neutralised if other methods are also applied to the case under investigation.

Illustrations of application of the Methods

1. Heat is the cause of the melting of ice.

Different methods can be applied to the case.

(a) *Method of Agreement* —In several cases we find that heat is present and the melting of ice is present.

(b) *Method of Difference*—We take a lump of ice and apply heat; it melts.

(c) *Method of Concomitant Variations*—The greater the heat, the sooner the ice melts. The degree of heat and the rate of melting vary concomitantly.

(d) *Joint Method* —In one set of instances, it is found that wherever there is heat, there is melting of ice; in another set, both heat and melting are absent, e. g., in refrigerators, in cold climates, in high altitudes etc.

The Method of Concomitant Variations is the most suitable here for conclusive result, because heat cannot be completely eliminated.

2. A sponge weighing 10 grams falls into water and weighs 18 grams. So the weight of water absorbed is 8 grams.

We apply the *Method of Residues* and find the weight of water by deducting the weight of sponge from the total weight of the sponge with water.

3. The eating of mangoes is the cause of summer boils.

(a) We apply the *Method of Agreement* and see that in a number of cases, both the phenomena are present, the causal relation becomes probable.

(b) We apply the *Joint Method* by taking two sets of instances. People who take mangoes have boils; but who do not take mangoes do not have boils. If we find that some people who take mangoes, do not suffer from boils and some others, who do not take mangoes, suffer from boils, we discard the hypothesis as wrong.

(c) We may apply the *Method of Difference* also to the case. A person, who suffers from boils every summer, is not allowed to take mangoes one summer. But even then he suffers from summer boils. In that case the hypothesis is discarded as wrong.

4. The occipital lobe in the brain is an indispensable part of the cause of vision.

It is obvious that only experiment can provide suitable cases for its study.

(a) *Method of Agreement*—The occipital lobe and the capacity to see are simultaneously present in several animals.

(b) *Method of Difference*—When the occipital lobe is removed from the brain, the animal loses eye-sight.

(c) *Joint Method*—In several cases we remove the occipital lobe and blindness follows, although before the removal of the lobe the animals gave evidence for eye-sight.

(d) *Method of Concomitant Variations* —The more the portion of the lobe is removed, the less is the capacity of eye-sight.

The result is reliable, because the conclusion is arrived at by experiment.

5. Overeating is the cause of indigestion.

(a) *Method of Agreement*—We may find out a number of cases of overeating and note that in every case it is followed by indigestion.

(b) *Method of Difference* —A man usually suffering from indigestion is kept under controlled diet and indigestion disappears.

(c) *Joint Method* — Two sets of instances are found out. In one set both overeating and indigestion are present. In another set both are absent.

(d) *Method of Concomitant Variations*— The intensity of suffering varies concomitantly with the quantity of excess food.

6. Medical practice is the cause of bad hand-writing.

The conclusion is drawn by the *Method of Agreement*. It may be proved to be fallacious by the *Method of Difference*, because a doctor who leaves medical practice, still writes a bad hand.

7. A piece of chalk weighing 5 grams is soaked in an ink bottle containing 25 grams of ink. The weight of the wet chalk is found to be 6 grams. So the weight of the remaining ink is only 24 grams.

We apply the *Method of Residues* and determine the weight of the ink absorbed by the piece of chalk to be 1 gram. The application of the method when repeated gives the weight of the ink left in the bottle to be 24 grams.

Criticism of the Inductive Methods

(i) The methods are not applicable to the complex phenomena of Nature.

The methods are applicable when the antecedents and the consequents are analysable into simple factors represented by A, B, C, a, b, c, etc. But in Nature phenomena are presented in a state of complexity. Whewell, therefore, complains that the methods take

for granted the very thing which is difficult to achieve. The difficulty is how to reduce the complex phenomena of Nature to simple factors. Mill admits that it is difficult to obtain the premises of Induction. He says that the methods are the valid forms of Inductive arguments. Causal connections can be discovered only when the phenomena conform to these forms. They are useful in so far as they give us an idea as to what forms the facts must be reduced to in order to enable us to establish a causal connection.

(ii) The Inductive methods cannot eradicate the difficulties arising out of the Plurality of Causes.

It is true that the plurality of causes is scientifically untenable and one effect has only one cause. But it is difficult to discover the one cause of the effect by the methods of Mill. We are interested to find out as to what exactly it is which always produces a particular effect. The Method of Agreement is thoroughly incapable of discovering this. By this method we only show that 'A' is uniformly present as an antecedent when the effect 'a' takes place. But 'A' may be an accidental factor whereas something, which is common in the apparently variable B, C, D, etc., may be the real cause. Multiplication of instances and the application of the Joint Method may show that B, C, D etc. do not contain the cause. But still it is not proved that 'A' always leads to 'a' though in this particular case it does lead to 'a'. The Method of Difference also shows that in a given case, a particular phenomenon is the cause. But it does not prove that it is the cause in *all* such cases. The other methods also being modifications of the Method of Agreement or the Method of Difference cannot establish a universal causal relation between two phenomena.

(iii) The Inductive methods cannot deal satisfactorily with cases of Intermixture of Effects.

The methods are applicable when the different effects are distinguishable. But in the case of an intermixture of effects, the effects of different causes are not distinguishable. A single

phenomenon is the effect of several causes operating jointly, e.g., a good crop is the effect of fertility of the soil, adequacy of water and weather, labour of the cultivator etc. It is not possible to determine exactly the share of each in the occurrence of the effect. The Method of Concomitant Variations and the Method of Residues are useful to some extent in such cases, but it can be said that in general the methods cannot satisfactorily deal with the cases of intermixture of effects.

(iv) The Inductive methods are not at all inductive but are really deductive in character.

In Induction we proceed from particular instances to a general principle whereas in Deduction we proceed from a general principle to a particular application of it. The inductive methods far from establishing a general principle are rather deductions from the law of causation. So Bain says, "These are called by courtesy Inductive Methods, they are more properly Deductive Methods, available in inductive investigation". Carveth Read says, "In fact Inductive logic may be considered as having a purely formal character. It consists, first, in a statement of the Law of Cause and Effect; secondly in certain immediate inferences from this law, expanded into the Canons; thirdly, in the syllogistic application of the canons to special propositions of causation by means of minor premises, showing that certain instances satisfy the Canons".

Mill defines cause as "the invariable and unconditional antecedent". Bain points out that from this definition the following principles of Elimination can be deduced.

1. "Whatever antecedent can be left out, without prejudice to the effect, can be no part of the cause".

2. "When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or a part of the cause".

3. "An antecedent and a consequent rising and falling together in numerical concomitance are to be held as Cause and Effect".

Joseph deduces further from the definition of the cause :

4. "Nothing is the cause of a phenomenon which is known to be the cause of a different phenomenon".

Taking these principles as the major premise and the results of observation and experiment as the minor premise, we can deduce syllogistically the results of the Methods thus :

1. *Method of Agreement*

Whatever antecedents can be left out without prejudice to the effect can be no part of the cause—Major premise.

B, C, D, E can be left out thus—Minor premise.
∴ B, C, D, E are no part of the cause—Conclusion.

But the law of causation states that every event must have a cause. So the method of Agreement concludes that the invariable antecedent 'A' is the cause of the invariable consequent 'a'.

Thus the Method of Agreement is nothing but a deduction from the law of causation and the principle of elimination which is deduced from the very definition of the cause.

2. *Method of Difference*

When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or a part of the cause—Major premise.

A cannot be left out thus—Minor premise.
∴ A is the cause or a part of it—Conclusion.

3. *Method of Concomitant Variations*

An antecedent and a consequent rising and falling together in numerical concomitance are to be held as cause and effect—Major premise.

'A' and 'a' are rising and falling together in numerical concomitance—Minor premise.
∴'A' and 'a' are Cause and Effect—Conclusion.

4. *Method of Residues*

Nothing is the cause of a phenomenon which is known to be the cause of a different phenomenon—Major premise.

B & C are known to be the cause of b & c—Minor premise.

∴B & C are not the cause of 'a' —Conclusion.

But 'a' must have a cause. So the remaining antecedent 'A' is the cause of 'a'.

5. *Joint Method*

POSITIVE SET

Whatever antecedent can be left out without prejudice to the effect can be no part of the cause—Major premise.

B, C, D, E can be left out thus—Minor premise.

∴B, C, D, E are no part of the cause—Conclusion.

NEGATIVE SET

When an antecedent cannot be left out without the consequent disappearing, such antecedent must be the cause or a part of the cause—Major premise.

A cannot be left out thus—Minor premise.

∴ A is the cause or a part of it—Conclusion.

Thus , it can be shown that all the Inductive Methods are deductive in character, and the criticism is justified.

It should be noted, however, that the minor premises in all the above cases state facts of observation and so the syllogisms are not simply formal but also material.

In conclusion, it may be remarked that Mill's aim of providing by his Experimental Methods the means of discovering and proving causal connections leading to the establishment of general real propositions of undoubted certainty has not been fulfilled. Mill's methods at best determine what cannot be the cause, i.e., both necessary and sufficient condition of one kind of events. But they

cannot *prove* or establish that something is definitely the cause of that kind of events. So to call them merely weapons or principles of elimination is not unjustified.

Mill called the Method of Difference to be the inductive method *par excellence* and a method of proof. Here we introduce something to a set of phenomena, and immediately the effect occurs.

So obviously what is introduced is a necessary condition. But it does not follow from this that what is introduced is also a sufficient condition and the cause of the event. So to call this or any of the methods as a 'method of proof' is a misnomer. The results of the methods are more or less probable, but never certain. In fact, no inductive generalisation, whether based or not on a causal connection discovered with the help of the methods, is claimed to be certain these days.

EXERCISE

1. What are Experimental Methods ? State and explain the canon of each method with the help of illustrations.
2. Explain the Method of Agreement. Why do Mellone and Coffey call this method the method of single agreement ?
3. Give an account of the Method of Difference. Why is it said to be mainly a method of experiment ?
4. What are the distinguishing characteristics of the Joint Method ? What are its advantages and disadvantages ?
5. Is the Method of Concomitant Variations a primary method ? Indicate its scope.
6. Why is the Method of Residues called a deductive method ? Compare it with the Method of Difference.
7. Examine the statement that the Plurality of Causes renders the results of the Experimental Methods doubtful.
8. The Experimental Methods cannot discover the cause in the case of Intermixture of Effects. Discuss.
9. Determine stating reasons :
   - (a) Which of the Experimental Methods are primary ?
   - (b) Which of the Experimental Methods are methods of discovery and which, methods of proof ?
   - (c) Which of the Experimental Methods are methods of observation and which, methods of experiment ?
10. Give a criticism of the Experimental Methods.
11. What are the Principles of Elimination ? How are they related to the Experimental Methods ?
12. State and explain which methods are applicable in the following cases. Are the statements justified ?
    - (a) Heat is the cause of the melting of ice.
    - (b) The eating of mangoes is the cause of boils.
    - (c) A piece of chalk weighing 5 grams falls into a bottle containing 25 grams of ink and weighs 6 grams. So the weight of the ink now in the bottle is 24 grams.

(d) Overeating is the cause of indigestion.

(e) The occipital lobe of the brain is a necessary condition of eye–sight.

(f) The increase in the number of crimes in a locality is due to the removal of the police–station from the locality.

(g) Scarlet flowers have no fragrance.

(h) Two pipes of unequal size can fill in 5 minutes, a tank which can contain 20 gallons of water. We know that the first pipe can fill only 5 gallons during this time. So the second pipe can fill 15 gallons of water in 5 minutes.

(i) Physical exercise increases strength.

(j) Presence of air is an indispensable condition for sound.

(k) The more the wealth, the more the comfort.

8

Methodology of Science

'Science' and 'Scientific' are commonly used words of our every-day life. But it is difficult to give an exact definition of 'Science', since it is used sometimes in a very wide sense and sometimes in a very narrow sense. It is, however, not difficult to point out what would not be considered as science. Nothing would pass as a science, unless it be a systematic body of knowledge, acquired through a predominantly logical method on a definite subject matter. A mere collection of all sorts of information about anything and everything acquired by any means would not be considered as a science. Further, every science establishes certain general propositions which are claimed to be as a matter of fact true.

The adjective 'Scientific' is generally used in a more wide sense than the corresponding noun 'Science'. Scientific enquiry is raising the questions 'how' ? and 'why' ?; Scientific measurement is precise and accurate measurement; Scientific thinking is controlled and directed thinking; Scientific attitude is the bent of mind which does not accept anything, unless it be reasonable and supported by evidence and so on. Bacon describes the scientist thus : The scientist is he who is ready to seek, slow to assert, prepared to doubt, yet quick to apprehend the resemblances between things, apt to distinguish their differences and careful to arrange them in order.

Kinds of Sciences

Some people use the term 'Science' in so loose a sense that even Palmistry or Astrology may claim to be reckoned as a science.

Some, again, use the term 'Science' in so restricted a sense that even Psychology has no claim to be reckoned as a science. The usual use of the term, however, is neither so loose nor so strict. We shall indicate briefly the nature of some disciplines, which are generally recognised as sciences.

Normative Science

Ethics, Aesthetics and Logic are taken to be normative sciences. It is said that each of these disciplines gives a systematic body of knowledge, since the processes of classification, establishing connections, generalisation, explanation and systematization are involved in the study of its subject–matter. But the ultimate objective of these sciences is not simply to describe facts as they are and to arrange them systematically, but to assess their value by judging them on the basis of a norm or ideal. Ethics judges the conduct or character of man and declares it to be good or bad. Aesthetics judges an object or situation and declares it to be beautiful or ugly. Logic judges an argument or reasoning and declares it to be valid or invalid. This primary assumption of the existence of a rule or standard is what distinguishes these sciences from others.

Formal Science

Logic is also taken, and more correctly, as a formal science, its normative aspect being a by-product of its formal nature. As such it is interlaced with Mathematics.

Formal sciences deal with forms rather than facts of experience. $1+2=3$; it is a mathematical proposition. It is immaterial what things—marbles, fruits or books — we take for illustration of this mathematical propositions. We are not concerned with the nature of objects here. We are concerned with only their numerical property. We are concerned here with the abstract numbers 1, 2 and 3. The proposition is independent of our experience. Experience may teach us that one atom of oxygen and two atoms of hydrogen turn out to be one molecule of water; one piece of glass with two

strokes of a hammer becomes innumerable pieces and particles of glass. These happenings depend on the nature of things. The truth of the mathematical proposition as stated above is not affected by the knowledge of the behaviour of things. Mathematics deals with necessary propositions, which are independent of experience. Similarly, a valid proposition of logic, e.g., 'If p, then it is not not-p' is a necessary proposition independent of experience.

Formal sciences are deductive. They start with a set of axioms, i.e., a set of propositions taken as fundamental and deduce all other necessary propositions or tautologies from them. They construct deductive systems.

Natural Science

It may be noted that though the word 'science' is used in a broad sense to include normative and formal sciences, and the word 'scientific' is used in a still broader sense, the word 'scientist' is generally used in a very narrow sense. A physicist, a chemist, a biologist or an astronomer is readily reckoned as a scientist, but an ethicist, an aesthetician, a logician or a mathematician is not generally called a scientist. Physics, Chemistry, Biology etc. are natural sciences. The natural science is science *par excellence* and in the narrowest sense, science means only the natural science.

From the point of view of its subject-matter natural science may be defined as a body of factual knowledge. Facts are known through observation, through experience. So natural science is otherwise called Empirical science. Observation, however, is not restricted to simple observation with the help of our natural sense organs. It, of course, includes experimental observation and also includes observation through scientific mechanism. Gravitational field, wavelengths of light and sound etc. are considered observable facts only through this extended use of observation. We know now many facts about Mars and other planets by such mechanised observation with the help of the Satellites.

A mere collection of observable facts by any means, obviously, cannot constitute a natural science. It has to follow a specific method and it is this method which determines whether a given study is a natural science or not. So the method is made a defining characteristic of natural science.

The essential characteristic of the method that science adopts is its *faithfulness to facts.* Howsoever pleasing an opinion may be, unless it is corroborated by facts, it is of no value in science. Facts and facts alone are the final court of appeal for this method. Besides this, *ordering* and *systematizing* are also other essential factors of this method.

Now let us try to understand what order and system mean and what roles they play in the scientific method.

Order

An isolated fact, if not viewed as connected to other facts, is useless in science. A collection of disconnected facts also does not constitute a science. A child, who aimlessly picks up whatever shells he finds on the sea-shore, is doing nothing scientific. But if he starts arranging them in accordance with their size or colour or date of collection, he is placing them in an order, he is doing something what was done at the earliest stage of science.

Order is possible, when there are *elements,* i.e., individuals, objects or facts to be arranged. Further, there must be a *plan* according to which the elements are arranged. Different plans for arranging the elements give rise to different types of order. Different sciences have different types of order. In fact, the type of order used in a science determines the stage of development that the science has reached. Cohen and Nagel speak of four types of order that mark the successive stages of development of the sciences..

(1) Order through classification

This order consists in classifying facts. We have given names to different kinds of things as Coal, Crow, Tiger, etc. *Natural kinds* are

classes of things found in nature.The members of the same class resemble one another on important and numerous points and differ from others that do not belong to this class. Thus one crow resembles another crow in a large number of important attributes and differs from a crane. After the classification of things into natural kinds, these classes are brought under higher classes, and these latter classes under still higher classes. Thus all the classes are made items of a system.

Classification represents the lowest level of order. It may, however, be noticed even at this level that the natural kinds indicate certain invariable association of properties. The property of having horns is noticed to be invariably associated with the property of having divided hoofs in animals. So we can generalise this fact and have a law in biology. Further, in a well-developed system of classification in science, every class has a definite position in the whole system. And if we know the basis of classification, the properties of any given class can be inferred. So we see that the purpose of classification is ultimately to discover correlation and establish scientific laws. These laws, then, serve the purpose of explaining facts.

(2) Order through causal relation

This order consists in arranging facts as cause and effect. The cause is that which leads to an effect and the effect is that which results from the cause. In this order, a given element is the cause of one element, but it is also the effect of some other element. The disease Malaria is the cause of weakness of the patient, but it is the effect of bite of anopheles. So we discover causal series and then get a system, the items of which are causally connected.

Incidentally, this order is a temporal order since the cause-element can on no account succeed the effect-element. The cause-element is the antecedent, what goes before; and the effect-element is the consequent, what comes after.

In the progress of science, this order is higher than the classificatory order. The natural tendency of the scientific mind is not to be satisfied with knowing what things are, but to know how or why they are so. Causal order satisfies this curiosity. In general, causal connections are considered to be dependable, generalisations based on them are considered to be well-confirmed and explanations given through them are considered to be more satisfactory than those based on classification.

(3) Order through mathematically expressed uniformities

This order consists in arranging the elements by establishing quantitative relations among facts. This type of order is marked by precision and exactitude, without attaining which the scientific mind does not rest satisfied. So the generalisations made at the lower stages are refined and stated at this stage in the form of mathematically expressed uniformities. Boyle's law, for example, states that temperature remaining the same, the product of pressure and volume of a given mass of a gas is constant. It can be expressed as $PV = \frac{2}{3} KT$, where P represents pressure, V represents volume, K represents gas constant and T represents absolute temperature. Similarly, Galileo's law of falling bodies is expressed as $S = \frac{1}{2} gt^2$, where S is distance travelled by a body, g is acceleration due to gravity and t is time in seconds.

In an advanced science, the generalisations become more and more abstract. Galileo's law is about falling bodies near the Earth, but it has discarded reference to the bodies that fall. When generalisations are stated as mathematically expressed uniformities, it is easy to show how a given law is deducible from one or more laws. Thus the interrelation among the laws is realised and the system incorporating them becomes evident.

(4) Order through theories

This order consists in arranging the various generalisations reached at lower stages under more and more general laws till all of

them can be deduced from one or a few general principles. The wider the generality of a law the more it is removed from concrete facts of experience and the more its abstractness. So at high levels the general principles tend to become *theories*. Theories are different from laws. Laws of nature are discovered, but theories are constructed or devised. A scientific theory contains one or more terms, which do not denote anything that we can directly observe even by mechanical devices. Such terms, e. g., protons, electrons, neutrons, etc., of Physics or valence of Chemistry or Ego, Superego, Id etc. of Psycho–analysis are said to be theory terms and a statement containing one or more theory terms is said to be a theory. Some of these theoretical entities are believed to be really existing, e.g., those of Physics; and some are considered to be merely 'convenient fictions', e.g., those of Psycho-analysis. But in any case theories have enormous explanatory power and without them a vast number of phenomena would remain unexplained.

The order brought about by the introduction of a theory is of a very high type. Many laws which apparently seem to be unconnected are shown to be deducible from the theory and vast areas of human knowledge become well organised. Thus every theory sets forth a deductive system. The theory of relativity of Einstein has systematized knowledge in physics in a very convincing manner, which no other theory ever did. It has made physics to a very large extent a well-knitted body of knowledge.

System

When facts are arranged in an orderly way, what we get is a system. Order refers to the *manner* in which facts are unified, but system is the *result* of this orderly arrangement.

In ordinary language also we use the term 'system' though not with any very precise connotation. We talk of the solar system, the social system of a tribe, the administrative system of an organisation and so on. The minimum requirement for a system seems to be that it must have several constituent elements, which are not only com-

patible with one another, but also admit of an arrangement by some mode of connection. A system is said to be *coherent*, if each of its elements is related to every other element in the system. A *deductive system* is a special kind of coherent system, where the elements are propositions and the relations between the elements are logical relations. Formal sciences, i.e., Mathematics and Logic construct deductive systems; Empirical sciences aim to do so. The deductive system of formal sciences are said to be *pure*, because they are self-sufficient. In order to demonstrate any proposition of such a system, there is no need to go outside the system. In such a system, a small set of propositions is selected as axioms or primitive propositions and from these axioms all other propositions of the system are deduced with the help of some definitions and some rules of procedure. With different sets of axioms different deductive systems can be constructed but each deductive system is a coherent whole and every proposition in it is deducible from other propositions inside the system. It is possible for formal sciences to build such *pure* deductive systems, since the propositions they deal with are independent of experience. The validity of such a proposition depends on its derivability and not on experience. Empirical sciences, on the other hand deal with propositions, which must refer to facts of experiences. So the deductive systems built in Empirical sciences are *impure*. The truth of a law in an empirical science does not depend on its derivability from higher law or laws, but depends on its verifiability whether direct or indirect with reference to facts of experience. So the deductive systems of empirical sciences have to be impure.

Empirical sciences have gone on building more and more well-organised deductive systems of higher and higher generality. At the lowermost level, we find generalisations from the knowledge of particular instances of classes of things. Direct evidence verifies these generalisations and they lead to the discovery of laws of nature. We get a system of laws of nature, when they are found to

be interrelated so that each law reinforces the other laws of the system. At this stage, when direct evidence justifies the truth of one law, the truth of the other laws of the system is also automatically confirmed indirectly. So direct evidence for one supplies indirect evidence for others, Similarly, when direct evidence falsifies a law, it becomes necessary to discard or modify some other laws of the system.

All laws entering into a system need not be of the same level. Some of them may be of higher generality from which the others may be deduced. Then, the organisation of the laws does not remain *horizontal*; it becomes *vertical*. The highest level laws are at the top of the system. From them the lower level laws are deduced and from them still lower level laws are deduced and so on. The lowermost level laws are at the bottom. In such a system, direct evidence in support of the lowermost level laws naturally supply indirect evidence in support of the laws higher up and the whole system is taken as established, when such evidence is available.

Different sets of highest level laws establish different systems and usually we get a number of systems in one science. But the aim and ambition of every science is to organise all the facts, phenomena and laws within its scope in a single deductive system. With the progress of science, deductive systems covering larger and larger fields of experience are built. The Newtonian system covered quite a large field of physics. Now the Einsteinian system, having the theory of Relativity at the apex, has covered a still larger field, incorporating within itself the entire system of Newtonian physics. But still the whole of physics has not yet been brought under a single system, though it is admittedly the most developed among the empirical sciences.

Scientific Method

Broadly speaking, any well-planned systematic method of doing work may be said to be scientific. But strictly speaking, Scientific method is the method adopted by the scientists in acquir-

ing knowledge pertaining to empirical sciences. Different sciences deal with different kinds of subject-matter, have different types of problems to solve, formulate different modes of laws. So the methods adopted by different sciences are likely to differ from one another. But every science to be considered as a science at all must adopt such a procedure that would make observations accurate, understanding clear, explanation satisfactory and knowledge systematic. So it is also not unlikely that scientific investigations would follow a common pattern of procedure which should be predominantly logical.

The scientific method usually has five steps. In different investigations different steps get prominence and in some cases some steps may not be necessary at all. So the scientific method as described below is only an ideal procedure, which is adopted with necessary modifications as the concrete situation demands.

Ist Step : Science has grown out of man's instinct of inquisitiveness and the desire to perfect his knowledge. So the initial step of any method of acquiring empirical knowledge is bound to be observation of facts and classifying them. Scientific investigation begins when a fact of observation appears peculiar and does not admit of usual explanation. The need is felt to account for this fact by connecting it with a total situation in which its occurrence would be normal and not unexpected. It should be noted, however, that where a layman sees no problem at all, the scientist may see one. The scientist's curiosity is unlimited. Something may seem obvious to the plain man because he is familiar with it. But to the scientific mind, it may present an occasion that holds out a problem demanding a solution..Nobody bothered about an apple falling from a tree. But it set Newton thinking and ultimately the law of gravitation was established. Professor Whitehead rightly remarks : "It requires a very unusual mind to undertake the analysis of the obvious". No scientific investigation is undertaken unless the problem is felt. So the Ist step of the scientific method is *observation and the feeling of a problem.*

2nd Step : Realisation of the problem leads the scientist to think out a solution that may suit the occasion. The solution may not appear very promising or he may hit upon a solution which may seem to be just the right one required. In any case, it is accepted tentatively for proper examination. Thus a hypothesis is framed. The formation of a hypothesis requires due consideration of relevant facts. But it is not easy to decide what is relevant and what is irrelevant to a particular problem. Something may appear absolutely irrelevant to the plain man in the context of the problem, but to the scientific mind it may appeal to be just the right thing that holds the solution of the problem under investigation. Extensive knowledge, deep insight and constructive imagination are factors that help in the formation of a proper scientific hypothesis, but there are no rules to success here.

In the present state of the advanced sciences, the hypothesis framed may be a non-instantial one involving theoretical entities. Much abstract thinking and many scientific investigations may be necessary before it is formulated and incidentally it may lead to scientific discoveries. While trying to suggest a hypothesis for the deviation noticed in the calculated path of *Uranus*, Neptune was discovered. While trying to explain the fogging of covered photographic plates near a vacuum tube, through which electrical discharges were passing, Roentgen discovered X-rays.

In any case, a problem needs a solution and a hypothesis is necessary to suggest a solution. So the 2nd step of the scientific method is *formulation of a hypothesis.*

3rd step : The initial hypothesis framed in the second step is a provisional supposition. It must be strengthened by collection of relevant facts. It guides the scientist to dispassionately make observations of or conduct experiments on all facts that have any bearing on his problem. He also examines how does his hypothesis stand in relation to the already established laws in the concerned field. These additional facts may lend support to his hypothesis as framed initially

or may require some modifications. In the alternative, they may show that the hypothesis is altogether wrong. In the former case, the hypothesis is retained as it is or modified as required. In the latter case, the hypothesis is discarded, another hypothesis is framed and again the process of examining relevant facts begins anew. Hitting upon the right hypothesis at the first stroke is a rare phenomenon. Usually, many wrong hypotheses precede the one that stands. It is said that Kepler had to reject nineteen hyhpotheses regarding the orbit of Mars, before he formulated the one that stands now, viz, Mars revolves in an eliptical orbit. Sometimes, even a very well supported hypothesis is exploded by the discovery of some new facts. Impartiality is a great virtue in scientific investigations and facts alone give the final decree about the correctness of a theory. So the 3rd step of the scientific method is *collection of relevant facts and modification of the hypothesis, if necessary, in the light of new facts.*

4th Step : The fourth step consists of deductive development of the hypothesis. This step is necessary specially in the case of a non-instantial hypothesis. Such a hypothesis cannot be directly tested since no instance exemplifying it are available. Theoretical entities by their very nature are unobservable. So from the hypothesis consequences are deduced. If the consequences are still not verifiable, further deductions are made from them. Thus we may have a series of deductions till finally the consequences relate to observable facts. Obviously, no deductive development is necessary where the hypothesis is directly concerned with observable phenomena. Harvey's hypothesis that the blood on every part of a body is of the same type can be tested directly and no deductive development is called for. But Freud's hypothesis regarding Ego, Superego and Id cannot be tested directly; deductive development is an essential step in this case.

5th Step : This step consists of *confirmation or disconfirmation* of the hypothesis. A hypothesis is disconfirmed, the moment facts running contrary to the hypothesis or its deductions are discovered

and no explanation for their occurrence in harmony with the hypothesis comes forth. The confirmation of the hypothesis is an unending process. The logical possibility of a scientific hypothesis turning out to be false in distant future cannot be eradicated. So the hypothesis is more and more confirmed in course of time, but never completely confirmed. It is taken as practically confirmed when the deductions are verified to be true and no contrary evidence is discovered in a considerably wide field of experience, leaving no reasonable doubts in the mind regarding the correctness of the hypothesis.

Now, let us consider what is the nature of the scientific method as described above.

Considering the logical reasoning involved in the scientific method, some have named it as the 'hypothetico-deductive' method in preference to the name 'inductive method', thus giving prominence on the framing of the hypothesis and on deductive development. If we compare it with what has been called by the former logicians as the 'inductive procedure', we find that the scientific method is similar to it. In fact, the steps of the procedure were determined by keeping in view the method followed in the sciences of those days.

The term 'inductive method'is used with a vague connotation. Sometimes, it is contrasted with 'deductive method' and sometimes, it involves 'deductive method'. Obviously, the scientific method as described above, involves both induction and deduction, if they be distinguished from each other. So if the scientific method is to be called an inductive method, we should bear in mind that 'induction' is used here in a broad sense and incorporates 'deduction'.

Science and Logic

Logic is not interested in the results of scientific investigation, but interested in the method employed in obtaining the results. It is not concerned with the truth obtained, but concerned with the manner in which it is obtained. The scientific method, i. e., the

procedure of acquiring scientific knowledge should be logically sound, or else its product cannot be accepted as true.

Knowledge of particular facts of experience got through direct observation, is accepted as true. But science is not interested in individual facts as such. It is interested in their being instances of some generalisations which again are required to be shown as parts of some system. So scientific knowledge is inferential knowledge grounded on facts of experience and the inferences involved stand in need of logical justification.

The logic involved in scientific method is sometimes described as induction and distinguished from the formal process of deduction. Bacon and Mill were of this opinion. It may be seen, however, that the scientific method as described above involves both induction and deduction. Mill defined 'induction' as the operation of discovering and proving general propositions. But it is clear that no proposition can be *proved* by inductive reasoning and general propositions may be discovered by deductive reasoning as well. Bacon's conception of scientific method was also defective. His distrust of hypothesis as 'anticipating nature' led him to hold a mutilated view of both the scientific method and the induction.

Bacon's contemporary scientists, Kepler and Galileo, held a very different conception of the scientific method.

Their method has been described as the Hypothetico-deductive method. Both Kepler and Galileo believed in the mathematical nature of the universe. Galileo's procedure of scientific investigation was first to formulate a hypothesis conceived in mathematical form, then to deduce the consequences of this hypothesis and finally to test the hypothesis by experimental observation. His aim was to show that the natural occurrences exhibit an order which can be predicted by reason. The prominence of mathematical deduction in advanced sciences and the observation of facts under the guidance of an initial hypothesis has led some logicians, e. g., Popper and Wisdom, to declare that scientific method is not at all based on induction.

It may be admitted that the present-day scientific method is not inductive in which induction was used by Bacon and Mill. The modern conception of induction, however, incorporates within itself both the formation of hypotheses and their testing by an appeal to facts. Further, it is also the method of establishing non-instantial hypotheses. It is in this sense of induction that scientific method involves induction. But in any case, it must be recognised that deduction has an important role to play in the scientific method.

Russell asserts that "in the final form of a perfected science, it would seem that everything ought to be deductive". This, however, has remained as an ideal. Broad rightly remarks that "whilst the inductions of all advanced sciences make great use of deductions, they can never be reduced without residue to that process".

In the building up of a scientific system, the scientific method has to proceed deductively within the system and inductively outside it. In establishing the lower most generalisations, the method has to be inductive and must refer to facts of experience. But to show that they belong to a system, they must be deducible from the highest level law or theory of the system. It is no good, therefore, to overestimate the importance of the one at the expense of the other.

The validity of a sound deductive reasoning is universally admitted to be unquestionable. It is not so in the case of a sound inductive reasoning. So the logical value of the scientific method involving both deduction and induction, naturally, depends on the logical value of induction.

Justification of Induction

The typical inductive reasoning is of the form :

Some S (observed) is P.
∴ All S (observed and unobserved) is P.

This argument is obviously invalid by the standard of deductive logic. It is a clear case of illicit process.

When by finding the consequences of a hypothesis to be true, we conclude that the hypothesis is true, in that case also the reasoning is invalid.

If H, then C.
C.
∴ H.

This argument commits the fallacy of affirming the consequent. In the face of these difficulties, is it possible still to claim that inductive reasoning is valid ?

It is admitted these days that the inductive reasoning cannot be valid like the deductive reasoning. It cannot be, for the simple reason that while deduction does not go beyond the premises, induction has to go beyond them. In order to justify the passing from the observed to the unobserved, the relation between the observed and the unobserved must be taken into consideration. If we assume that the unobserved cannot but be like the observed, it is only then that we can go beyond the observed to the unobserved, otherwise not.

In justification of induction, Mill advanced the principles of *uniformity of Nature and universal causation*. Keynes advanced the principles of *atomic uniformity and limited independent variety*. But whatever principles we assume here, they are about the constitution of the universe, and neither can they be taken as axiomatic nor can they be proved as true. So we shall have to concede that they cannot be claimed to be absolutely true. Consequently, the conclusion of induction, being based on them, cannot be certain as Mill claimed, but can only be probable. Even the humble claim that inductive conclusion is more likely to be true than to be false also cannot be demonstrated by any theory of probability.

This difficulty about the justification of induction has led Strawson and others to hold that the very procedure of justifying induction in the above way is unreasonable. Induction is not deduction. So the standards of deduction cannot and should not be applied to

it for its justification. It is no good asking whether induction can be justified deductively. Induction should have and does have its own standard of justification. Particular inductive generalisations can be judged to be correct or incorrect, according as they have sufficient empirical evidence or not. This is the inductive standard for evaluating an inductive reasoning.

But again, it is no good asking whether induction can be justified inductively. A particular act of a citizen can be judged to be legal or illegal according as it is in accordance with the law or not. But it is meaningless to ask whether law is legal. Similarly it is meaningless to ask whether induction is inductively justifiable. So these logicians object to the very process of justifying induction whether deductively or inductively.

Sometimes a pragmatic justification is given for the scientific method and consequently for induction. The scientist believes that nature is a system and it is a simple system; there are laws of nature and they are discoverable. These beliefs may turn out to be false, but they have not. The scientist in his attempt to discover the secrets of nature adopts a method which involves induction. He observes, experiments, classifies, frames hypotheses, deduces, verifies and through these gains knowledge of empirical laws. He predicts about the future and the predictions come true. He controls the normal course of nature for the benefit of mankind and is enormously successful in his attempt. The success of science provides ample justification for believing its assumptions to be true and its method to be correct.

This is how induction is justified pragmatically.

EXERCISE

1. What is Science ? Explain the nature of Normative and Formal Science.
2. What is Natural Science ? How does it differ from Formal Science ?
3. Explain the concept of order in Science. Write explanatory and illustrative notes on different orders.
4. Distinguish between order and system. Describe the nature of a fully developed system.
5. Explain the characteristics of :
   (a) Coherent system
   (b) Pure deductive system
   (c) Impure deductive system.
6. Explain the different steps of the Scientific method.
7. Is the Scientific method inductive ? Discuss.
8. Explain the relative role of induction and deduction in Science.
9. How is induction justified ?
10. Write notes on :
    (a) Order through theories
    (b) Deductive development of hypothesis
    (c) Indirect evidence.

9

Explanation

Explanation literally means making something plain. No explanation is called for in a familiar situation, where we know the objects and their characteristics. When we do not know something, do not understand a fact or a phenomenon, we ask the questions : What is it ? Why is it so ? It is a request for making it plain, a request for an explanation. When a description or definition is given, the what of the object is known. When a cause is assigned, the why of the phenomenon is understood. So description, definition and discovery of a cause are the ways of explaining things.

Explanation is satisfaction of some curiosity, solution of some perplexity. It is dependent on the purpose and previous knowledge of the individual who seeks for an explanation. A layman may be satisfied with the description of a plant under discussion which states some superficial features of the plant, but the botanist demands a definition of the plant, which must state the essential characteristics. A superstitious man may be satisfied if a supernatural agency is said to be the cause of a natural phenomenon, e. g., the eclipses are produced by a demon's swallowing of the sun or the moon, epidemics are due to the anger of gods or goddesses. A scientist is not satisfied with such explanations. He seeks for natural agencies for natural phenomena.

Every case of explanation involves the process of assimilation and discrimination. When a thing is assimilated to a class of things, it is partly explained. We say an aeroplane is a conveyance. A pen

is an instrument. A zebra is a horse. Here we have classified unknown things. We have put them in familiar classes. Similarly the disappearance of the sun or the moon was explained as a case of swallowing of things by animals. Further when we distinguish this particular object from the other individuals of the class we have further explained it. In the case of aeroplane, the distinguishing feature is 'flying in the air'; in the case of pen, it is 'used for writing' and so on. Similarly, a law is explained when it is brought under a higher law; a phenomenon is explained when it is shown to be similar to other phenomena; an event is explained, when it is shown to be an instance of a law of nature. When an object cannot be shown to be similar to other things, exlplanation fails. This may be due to either the lack of knowledge on the part of the persons concerned with explanation or the peculiarity of the phenomenon to be explained. Similarly, when an event or law cannot be brought under a higher law, explanation fails.

Popular Explanation

Popular explanation is an explanation of a fact or phenomenon without having resort to scientific means. Every explanation aims at satisfying the curiosity of the questioner, to set at rest his perplexity. Whatever does this is an explanation. The popular explanation may satisfy the curiosity of a layman, a novice, a beginner; but it does not satisfy the student who has made some progress in the knowledge of the subject on which the difficulty arises. So explanations can be graded from the most fantastic to the most scientific. All explanations falling short of a scientific knowledge of the subject may be described as popular. Formation of a legitimate hypothesis is the beginning of a scientific explanation.

Some of the features of Popular Explanation are :

(i) It is given by noticing some superficial points of similarity, e.g.. Death is discarding a useless body as a useless house is discarded.

(ii) It very often explains natural facts by supernatural agencies, e. g., famines are due to wrath of gods.

(iii) It is mostly concerned with the explanation of particular facts that appear abnormal.

(iv) It is unsatisfactory and sometimes partial from the scientific point of view.

Scientific Explanation

At the early stage of science, scientific explanation consists in stating the cause of an event. At the later stage, scientific explanation consists in showing the event to be an instance of a law of nature. The law itself is explained by higher laws and the latter laws by still higher laws till we reach at the ultimate laws or theories of the present age. Though these ultimate laws or theories cannot be explained now, the possibility of explaining them by still higher theories in future is not ruled out. So scientific explanations are the means of systematization.

Carveth Read says, "Scientific Explanation consists in discovering, deducing and assimilating the laws of phenomena".

Accordnig to him, a fact is scientifically explained when we discover its cause. When the cause in unknown, we begin with a hypothesis, deduce conclusions from the hypothesis and verify them. To discover a causal connection we first assimilate the fact to other similar facts, i. e., we bring it under a class. When the cause is discovered, it explains not only the fact calling for explanation but also all similar facts. Thus the causal connection is generalised. A particular fever is recognised as Malaria and hypotheses are framed to discover its cause. When the cause is discovered, it explains all cases of Malarial fever.

A law is scientifically explained when it is deducible from a higher law. Thus the law of planetary motion was explained when it was shown to be an instance of the law of gravitation.

Some of the features of scientific Explanation are :

(i) It seeks for essential points of similarity.

(ii) It explains natural facts by natural agencies.

(iii) It aims at understanding the nature of events and establishing general laws of wider and still wider scope.

Now let us try to understand the process of explanation of well-developed sciences in some greater details.

The general and ideal pattern of scientific explanation assumes the form of a deductive inference. What is to be explained is called *explicandum*. What are advanced to explain it are called *explicans*. The explicans justify the explicandum as the premises justify the conclusion. But a distinction is drawn between giving *reasons* and giving *explanations*. Reasons are given for our beliefs, opinions, assertions etc., whereas explanations are given for events, processes and happenings in the course of nature. As reasons for my belief in ghosts, I shall have to give arguments in support of the existence of ghosts. But the explanation for my having the belief lies in my hearing ghost stories in childhood and fear.

Scientific explanation is given with the help of laws or theories. It may be either of an individual fact or of a law.

In order to explain an individual fact, besides stating the law or the laws involved, it is necessary to state the circumstances, the properties of the individual fact, i. e., the *initial conditions*, which render the individual fact an instance of the law or laws. For example, to get the explanation as to why is our friend suffering from malaria, it is not enough to know that bite of anopheles mosquitoes causes malaria (law). We should also know the peculiar circumstances of this particular case, viz., his living in an area abounding with anopheles, his habit of not using mosquito curtain etc. If we do not know these initial conditions, the law alone cannot explain as to why out of all persons, he suffered from malaria and not somebody else. So here the explanation is of the pattern :

$(L + C_1 + C_2 + C_3 + ...) \rightarrow E$, i. e., the law (or laws) and the initial conditions have led to the occurrence of the event.

In order to explain a law, which is itself a general proposition, more general law or laws are required. The law of planetary motion is deduced from the law of gravitation. The law of the projectile's movement in a curved line is explained by Newton's law of motion, law of gravitation and the law of resistance. So here the explanation is of the pattern :

$(L \text{ or } L_1 + L_2 + L_3 + \text{--------}) \rightarrow L$. The laws inside the brackets must contain at least one law which is more general than the law deduced.

The explanation to be satisfactory, the laws or theories with which the explanation is given should have been established earlier by independent evidence either direct or indirect. Further, they should have some predictive value, showing that they are grounded in facts and not mere fictions of the mind. If the explicans themselves be of doubtful nature, naturally, the explanation fails.

Types of Scientific Explanation

According to Mill, Scientific Explanation may be of three types :

(1) *Analysis* — It means analysing the several causes which acting together produce a joint effect, e.g., the path of a football thrown to the air may be explained by the initial force, the force of gravitation and resistance of the air.

(2) *Concatenation* — It means tracing the intermediary links between a remote cause and its remote effect, e.g., sea water explains rains by the intermediary processes of evaporation, condensation,electric discharge etc.

(3) *Subsumption* — It means inclusion of a law under a higher law, e.g., planetary motion is explained when the law of such motion is brought under the law of general gravitation.

According to Earnest Nagle, Scientific Explanation may be of four types :

(1) *The deductive model explanation* :— Here the explicandum is logically deducible from the explicans. The falling of flowers under the plant can be explained by the law of gravitation and the condition of their being detached from the plant. Newton's law of gravitation itself is explained by Einstein's theory of Relativity by this type of explanation. This is considered to be the most satisfactory form of explanation.

(2) *Probabilistic explanation* —Here the explicans are laws in a loose sense. Most children lacking love and affection in their early life tend to become juvenile criminals. Bobby lost his parents and was treated cruelly by his relatives. That explains why he is a juvenile criminal now.

Explanation with the help of statistical laws is also Probabilistic. By cross-breeding a tall pea plant with a dwarf pea plant, suppose, we got a tall pea plant. This is explained by Mendel's law that about 70 % of the offsprings inherit dominant characteristics of the parents and tallness is a dominant characteristic.

(3) *Teleological or Functional explanation*— Explanations given in terms of *telos* (end) or purpose is the most primitive type of explanation. Some of the actions of conscious beings, specially human beings, cannot but be explained by pointing out the purpose. Why did Kaikeyi ask for the banishment of Ram ? The purpose was to enable her son, Bharat, to rule over the kingdom peacefully. Sometimes unconscious purposes are invoked by Psychiatrists in explanation of some abnormal behaviours of human beings. The mother unconsciously desired that the son should not be married. That is why she became so unhappy and committed suicide after the marraige, which she herself arranged. These are teleological explanations.

Sometimes, 'purpose' is used in a much diluted sense. Why are there eyes ? The purpose is to see. What is the purpose of the heart ?

To pump blood through the body. Obviously, 'purpose' is not being used here in the sense of intention, conscious or unconscious, since eyes and heart are not living beings. More properly, we should say here 'function' instead of 'purpose'. These are functional explanations.

(4) *Genetic explanation* — This type of explanation is given in the case of a process involving a developmental law. A developmental law describes the different phases through which a process takes place from the start to the end. The grapes pass through a number of phases in the chemical process of fermentation in order to become brandy. The traits of a child develop from the original combination of genes through a biological process. To explain a phenomenon of a particular stage, we take the help of Genetic explanation.

The states of diseases, some historical events, many cultural practices can be satisfactorily explained by this type of explanation.

Limits of Scientific Explanation

When a phenomenon cannot be assimilated, it cannot be verbally explained. So the following cannot be thus explained :

(i) Elementary sensations, e.g., colour, taste, smell, pleasure, pain etc.

(ii) Primary qualities of matter, e.g., extension, resistance, motion etc.

(iii) Individual peculiarity of objects cannot be exhaustively explained, e.g., personality of a man, peculiarity of an individual fruit etc.

(iv) Axioms and ultimate principles, e.g., law of Identity, law of Uniformity of Nature etc.

The only way of having knowledge about elementary things and qualities is direct experience. When somebody asks what is a pentagon, we may give him an idea of a pentagon by saying that it is a plane figure bounded by five sides. But when somebody asks what

is scarlet colour, the only way to give an idea about it is to point out an object of this colour.

Axioms are self evident assumptions of widest generality. So they are beyond explanation. Ultimate thories indicate the limit of generalisation that science has reached. In future they may be explained and may be shown not to be ultimate. But as long as they are taken as ultimate, there are no higher theories than them and thus they cannot be explained.

Illusory or Fallacious Explanations

Illusory Explanations are those which appear like explanations but are really not so. Bain mentions three forms of such Illusory Explanation :

(i) Repeating the same fact in a different form of language, e.g., opium produces sleep, because it is soporific; 'soporific' means sleep producing. We see through glass, because it is transparent; 'transparent' means offering no obstacle to sight.

(ii) Taking familiar facts as simple, e.g., falling of an apple is taken as simple and therefore self-explanatory. But Newton had great difficulty in explaining it.

(iii) Explaining the clear by the obscure, e.g., Kant tried to prove the existence of phenomena or sensible things by noumena which are beyond sensibility. Here we cross the limit of scientific explanation. When the ultimate general laws are reached, we can-not push explanation further to establish them. They are taken as fundamental features of the universe. Any attempt to explain them will land us in the domain of Metaphysics.

Besides these, all Popular Explanations are fallacious from the scientific point of view.

EXERCISE

1. What do you mean by explanation ? Explain how it involves the processes of assimilation and discrimination.
2. Distinguish clearly with examples between Popular and Scientific Explanation.
3. What are the different forms of Scientific Explanation according to Mill and according to Earnest Nagel ? Explain and Illustrate.
4. Explain with examples the different forms of Illusory Explanation. How do they differ from Popular Explanations ?
5. Give an analysis of the process of explanation in a well developed science.
6. Examine the following explanations and state whether they are scientific or not :
   (a) He is a Judge, because he performs judicial function.
   (b) Ice is water solidified due to cold.
   (c) Rain is due to the sprinkling of water by Airavata
   (d) Lion is an animal.
   (e) A man dies when his vital functions cease to work.
   (f) Leprosy is due to the sins of the previous life.
   (g) China is the country of the Chinese.

10

Laws of Nature

Observation shows that natural phenomena of a particular class behave in some uniform manner. Material bodies uniformly gravitate. Living oganisms have a uniform course of origination, growth, decay and destruction. "A law of Nature is the expression in language of some uniform relation existing among the phenomena of a particular class." There are different laws in the different departments of Nature. But these laws seem to be essentially connected together, making Nature an organised whole. So Nature is described as a cosmos, not a chaos; it is a unity, not a bundle of uniformities; a system of laws, not an aggregate of laws. The progress of sciences discovers not only laws or uniformities among phenomena which appeared at first unconnected, but also relation of subsumption among laws and relation of inter-dependence among laws, thus building up systems of wider and still wider generality.

Laws of Nature as uniformities may be distinguished from laws of State as command of the State authorities, and laws of the Normative sciences as regulative principles for the realisation of their respective ideals. Laws of the State are changeable and violable. They change from State to State and from time to time. They are man-made and can be violated. The laws of the Normative sciences like Logic, Ethics and Aesthetics cannot be changed but can be violated. If we wish to get truth by reasoning, we must observe the rules of reasoning; we cannot change them according to our will; but we may violate them, though truth remains unrealised. The

Laws of Nature, on the other hand, are neither changeable nor violable. Man can neither change the law of gravitation nor violate it by jumping from the top of a house and not descending to the ground. Further, the laws of the Normative sciences are normative and prescriptive, stating what we should do to realise the ideal, whereas the laws of Nature are positive and descriptive. They describe how natural phenomena do behave, and thus enable us to explain and predict occurrence of events in nature.

Empirical Generalisations and laws of Natural Sciences

Empirical propositions are those statements, the truth of which is testable by an appeal to experience directly or indirectly.

Empirical propositions about single things, e.g., The mango I am eating is sweet; This dog is black; This Cuckoo is dead, are neither generalisations nor laws. Such propositions provide materials for empirical generalisations and laws of natural sciences, but by themselves they are not generalisations. When we notice several individuals having a common characteristic and express this fact by a proposition, it is a generalisation. The primary source of generalisation is induction per simple enumeration.

Let us consider the following generalisations :

(a) Some mangoes are sweet.

(b) Most snakes are poisonous.

(c) 90% of diarrhoea patients are cured by taking sulpha drugs.

(d) All dogs in this kennel are black.

(e) All lions are tawny.

(f) All lions are mortal.

(a) is a statement about an indefinite number of mangoes. It is not a universal statement. It has no predictive or explanatory value. We cannot infer from this whether the mango in my hand is sweet or not. It cannot be considered as a law in science.

(b) is said to be an approximate generalisation. Most means more than half.

(c) more definitely states the proportion of the subject class as having the property indicated by the predicate.

Propositions of the type (b) and (c) are sometimes loosely termed as *Statistical laws,* because they have some practical utility. We would guard against a snake since it might have been poisonous; we would recommend administration of a sulpha drug in the case of a diarrhoea patient. But these generalisations would not pass as *Scientific laws,* because they lack universality and dependability, which are characteristic features of scientific laws.

(d) has the form of a universal proposition, but it is not of unrestricted generality. It is a statement about a limited number of observed cases restricted in respect of time and place. This is a statement about a fact not a law of science.

(e) is a universal proposition of unrestricted generality and would appear to have a fair claim to be considered as a law. Yet it is not generally reckoned as a law in science, because it expresses a uniformity involving an accidental characteristic of animals. Animals of the same species are noticed to differ in colour and we shall not be surprised if a lion of a different colour is discovered. This discovery would not affect any other law, and would lead us to abandon the assertion without hesitation since direct evidence was the sole support of the truth of the statement. Usually, a scientific law is supported by indirect evidence also.

(f) is not only a universal proposition of unrestricted generality, but is supported by both direct and indirect evidence. Mortality is connected with animality, which is an essential characteristic of lions. Not only lions but all living beings were noticed to be mortal. So it would naturally lead to much surprise if ever a lion is discovered to be alive for several centuries and we are required to admit that it is immortal.

This proposition is connected with several other uniformities like mortality of organisms in general, the bio-chemical deterioration of tissues, the increase in autoallergenic response etc. These other laws provided indirect evidence in support of (f). So falsification of (f) would necessarily mean modification or rejection of a number of laws, which along with (f) constituted a scientific system.

Scientific laws are embedded in a wider system of laws. The laws of higher levels have enormous indirect evidence and have great explanatory and predictive value. So they cannot be easily dislodged or lightly discarded.

A scientific law is not abandoned forthwith, even if some misfitting phenomenon is discovered. Attempts are made to save the law by advancing some *ad hoc* hypothesis in explanation of the recalcitrant phenomenon. So it may be realised that any and every generalisation is not a law in science; scientific law cannot be easily established and cannot be easily discarded.

In the light of the above discussion, we may define scientific law or law of nature as a universal proposition of unrestricted generality having indirect evidence in its support and the power to explain and predict accurately observable facts and phenomena.

Classification of Laws of Science

From the standpoint of generality, Laws may be of three kinds, viz., (i) Axioms (ii) Primary Laws, and (iii) Secondary Laws.

(i) Axioms

Axioms are self-evident propositions of the highest generality in their own spheres, which are taken as basic assumptions.

Axioms are so self-evident, that the mind immediately recognises them to be true and no proof is necessary. Any attempt to prove them fails, because they are themselves the ground of all proofs in their respective departments. Every department of science has its own axioms.

Axioms of formal sciences, like Mathematics and Symbolic logic are tautologies. They are verbal propositions independent of experience. A set of propositions may be taken as an axiom-set, if it is characterised by consistency, completeness and independence. All other tautologies of the system are derived from the axioms with the help of some definitions and rules of operation. In these sciences, it is possible to take alternative axiom-sets, and build different deductive systems. The axioms of non-Euclidean geometry are different from those of Euclidean geometry. So there is no question of any absolute axiom-set.

Axioms of empirical sciences are real propositions, which are assumed to be true. On the basis of them, theories and laws are advanced. The law of gravitation is based on the axioms of Newtonian mechanics. If the axioms change, naturally the theories and the laws based on them also change. Einstein accepted a different set of axioms from that of the Newtonian mechanics and advanced the theory of Relativity. A law of a system of empirical science, however, may change even when the axioms remain the same. This happens, when disconfirming evidence falsifying the law comes to notice.

Some logicians consider the axioms of a science as the laws of widest generality of that science. But generally, a distinction is made between Axioms and Laws. The former are assumptions that are neither proved nor disproved. But the latter are established either deductively or inductively by direct or indirect evidence.

(ii) Primary Laws

Primary laws are also called the Ultimate laws, because they indicate the ultimate that a science has reached. When a law of further generality than an accepted primary law is reached from which it can be derived, then it is no longer considered as a primary law. Primary laws are dependent on the progress of the concerned science. The General Law of Gravitation was accepted as a primary law in physics. But it is no longer considered to be primary now, since

it is derivable from the theory of Relativity. At present, theory of Relativity is a primary law of physics. The primary law of advanced sciences are non-instantial hypotheses. The Law of Conservation of energy, the Law of Definite proportion, the Law of Heredity etc. are other examples of accepted primary laws of the present age. Other laws can be derived from them, but they cannot be derived from any law of higher generality other than the Axioms. They are, however, established by inductive methods and compatible with the axioms. So they are not beyond proof as the Axioms.

(iii) Secondary Laws

Secondary laws are less general than the primary laws. They have limited spheres of application. They are called 'intermediate generalities' as they are like the steps for rising to the primary laws.

Secondary laws have been divided into several subclasses.

They may be either Derivative or Empirical.

Derivative Laws

A Derivative law is derived deductively from the primary or the ultimate laws. It may be deduced either from one primary law or from several of them. The law of tides is derived from the law of gravitation. The law of motion of the projectile is derived from the law of gravitation, Newton's law of motion that a body moves in a straight line, and the law connected with the resistance of air.

Empirical Laws

Empirical laws are those which we get by generalisations from experience. Scarlet flowers have no smell. Tom-cats with blue eyes are deaf. These are generalisations which have been found to be true, but have not been shown to be derivable from higher laws. These laws are established inductively by direct evidence or by both direct and indirect evidence. They differ from non-instantial hypotheses which have only indirect evidence in their support.

Empirical laws become derivative when they are deduced from higher laws. 'High mountains are snowcapped' was considered to be

an empirical generalisation but it has become derivative now, since it can be deduced from the law or radiation of heat.

Secondary Laws may be either Invariable Generalisations or Approximate Generalisations.

Invariable Generalisations

Invariable generalisations are those Secondary laws which are universally true as far as our experience goes, e.g., All lions are tawny; All men are mortal. In these cases no exception has come to our notice.

Approximate Generalisations

Approximate generalisations are those Secondary laws which are true in most cases but there are exceptions, e.g., most swans are white, most men are selfish.

Strictly speaking Approximate generalisations are not laws, but they cannot be said to be useless. When the exceptions are definitely known they are as good as Invariable generalisations, e.g., 'Most metals are solid' is a particular proposition equivalent to 'Some metals are solid'; but "All metals except mercury are solid" is a universal proposition.

Invariable generalisations sometimes degenerate into Approximate generalisations when exceptions are noticed. 'All swans are white' was considered to be an Invariable generalisation, but since black swans have been discovered in Australia, the generalisation now is only approximate. Approximate generalisations are also useful when based on statistics, e.g., 90 %(most) of the people suffering from x–disease are cured by y–treatment.

Carveth Read says that Secondary Laws may be divided into Laws of Succession and Laws of Co-existence.

Laws of Succession

Laws of succession are obtained from causation. They may be a relation between :

(i) cause and effect, e.g., water quenches fire;

(ii) remote cause and remote effect, e.g., intemperance leads to early death;

(iii) co-effects of the same cause, e.g., spring follows winter.

Laws of Co-existence

Laws of co-existence may be derived :

(i) by the Method of Agreement, e.g., gravitating bodies are inert;

(ii) from the properties of natural kinds, e.g., insects are six legged;

(iii) from uniform coincidence of inessential qualities, e.g., scarlet flowers have no smell;

(iv) from constancy of relative position, e.g., rectilineal plane figures bounded by 'n' sides have 'n' angles;

From the standpoint of the nature of order introduced into empirical facts, Scientific laws may be of five types.

(i) *Classificatory laws* : These laws are established by noticing the properties that are invariably found in a natural class of things or what is called a natural kind, e.g., Oxygen is a colourless, odourless and tasteless gas that has the atomic number 8, atomic weight 16, boiling point—182·96° centigrade. Chinarose is a flower which is monadelphous, has anthers free and reniform, carpels 5 and a style passing through the staminal tube.

(ii) *Causal laws* : These laws are established by noticing necessary and sufficient conditions that led to the occurrence of a kind of events, e.g., Humidity rusts iron, Heat expands bodies.

(iii) *Developmental laws* : These laws are established by tracing the different steps of a kind of process from the earlier phases to the later phases, e.g., The law of the growth of the foetus in the mother's womb. The law of the course of a particular type of disease.

(iv) *Statistical laws* : These laws are established by noticing the percentage or proportion of a class of things as invariably having certain properties, e.g., 75% of the offsprings inherit dominant characteristics of the parents (Mendel's law); 50% of the mass of a radioactive element decays in the course of a fixed time depending on the nature of the element (law of the half life period).

(v) *Laws of functional dependence* : These laws are established in mathematical terms by noticing the constant correlation between properties, e.g., $E=mc^2$, where E is energy, m is mass and c is velocity of radiation; At constant temperature, $PV=$a constant, where P is pressure and V is volume.

EXERCISE

1. Distinguish between laws as uniformities, laws as commands and laws as regulative principles. Illustrate your answer with suitable examples.
2. Attempt a classification of laws from the standpoint of generality and write notes on each class of laws.
3. Distinguish between :
   (a) Emperical law and Derivative law
   (b) Axiom and Primary law
   (c) Approximate generalisation and particular proposition.
4. Write explanatory notes on :
   (a) Invariable generalisation
   (b) Law of succession
   (c) Law of co-existence
   (d) Developmental law.
5. State what sorts of law are the following :
   (a) If p implies q and q implies r, then p implies r.
   (b) The total amount of energy in the universe remains constant.
   (c) Two atoms of Hydrogen and one atom of Oxygen taken together produces one molecule of water.
   (d) The greater the heat and the heavier the rain, the taller the trees and the fatter the animals.
   (e) The higher you go, the cooler you feel.
   (f) Most birds fly in the air.
   (g) You should speak the truth.
   (h) The probability of a coin falling heads is 50%.
6. Are all empirical generalisations laws of science ? Discuss.

11

Classification

Classification is defined by Carveth Read as "a mental grouping of facts or phenomena according to their resemblances and differences, so as best to serve some purpose".

Classification is a mental grouping because in classifying a number of things, we need not physically put them into different groups. When we classify human beings into tall, short and medium-sized, we only mentally put them in different groups. Objects which resemble one another are put in one group; objects which differ from the first group but resemble among themselves are put in a different group and so on. In the above case, all tall men resemble one another in being tall and differ from the short and medium-sized men. Similarly, the short men resemble one another and differ from others.

A classification is made for some purpose. In the above case, we wish to study men from the standpoint of height. We could have classified them differently for a different purpose. Thus, the same human beings could have been classified into Hindu, Muslim, Christian etc., from the standpoint of religion or into healthy and unhealthy from the standpoint of health.

It appears that classification is the same as division, but a line of distinction is drawn between them.

It is true that both have to do with a systematic arrangement of the denotation of a term; but even then they may be said to be poles apart, because they begin systematisation as if from the opposite

poles. Division begins with a class, divides it into lower classes and these lower classes into still lower classes and so on. Classification, on the other hand begins with the individuals, puts them into classes, these classes into higher classes and the higher classes into still higher classes and so on. Division begins from the top and proceeds downwards. Classification begins from the bottom and proceeds upwards. Division proceeds from unity to multiplicity; classification proceeds from multiplicity to unity.

Division is deductive but classification is inductive. Division proceeds from the more general to the less general; classification proceeds from the less general to the more general. Division is a formal process but classification is a material process. We divide the genus but classify the individuals.

In division we begin with a logical whole, but in classification we begin with concrete things.

Thus the processes are not identical but allied.

Forms of Classification

Classification may be of two kinds : (i) Natural or General Classification, (ii) Artificial or Special Classification.

Natural Classification : "Natural classification is the mental grouping of individual objects, according to the most numerous and important points of similarity for the purpose of acquiring general knowledge". It is called Natural classification because the classification has been made by Nature herself. We find in Nature, "Natural Kinds", i.e., natural classes like cow, horse and elephant. The individuals of each class have similarity in most numerous and important points. We are simply to recognise them. It is called general classification, because the purpose is to have a general knowledge about the individuals thus classified. It is also called scientific classification, because such classification serves the purpose of science, which aims at acquiring a knowledge of things as they actually are. By Natural classification, for example, we begin with the individual

animals and put them into different 'Varieties'. These varieties are grouped under different 'Species'. Species come under 'Genera'. Classification then gradually rises to 'Tribe', 'Order', 'Subkingdom' and ultimately to 'Kingdom'. This is also the classification of a Zoologist.

Artificial Classification : Artificial classification is "the mental grouping of facts according to some points of similarity, selected arbitrarily for a special purpose". It is called artificial classification, because we ignore the most numerous and important points of similarity and arbitrarily select some feature as the principle of such classification. It is called special classification, because we classify thus for a special purpose and not for the purpose of gathering general information about the individuals. Thus, for example, the manager of a Zoo may classify animals as big and small to provide abodes for them, or may classify them alphabetically for the convenience of the visitors to remember, and so on.

Some logicians, e.g., Welton, raise objections against the use of the terms Natural and Artificial as applied to classification, because all classifications may be considered artificial in one sense and natural in another sense. Every individual thing has infinite qualities and in every classification we have to select some qualities as the basis of classification ignoring the others. Further, we ourselves make the selection and different scientists may classify differently. The Theory of Evolution shows that there are not fixed immutable classes and consequently there is no fixed natural classification. So in this sense all classifications are artificial. In another sense, all classifications are natural, because whatever quality be selected as the basis of classification, the quality actually exists in the objects of Nature. Even when the librarian classifies books in the alphabetical order, the books do bear the names and the similarity, howsoever superficial, does exist. The librarian only discovers this similarity and classifies the books. Welton prefers the terms 'classification for special purpose' and 'classification for general purpose'. Others

prefer the terms 'scientific classification' and 'popular classification.' In view of the above objections, we may discard also the use of the terms 'objective classification' and 'subjective classification.' But in any case, the distinction between the two forms of classification is recognised by most logicians whatever be the terms used.

Classification by Series : It was Comte who recognised first the importance of Classification by series. It is the arrangement of classes in a series according to the presence of a quality or qualities in varying degree. For example, we put in a broad class all living beings and arrange the different sub-classes in a serial order beginning with man and ending with plants on the basis of complexity of the organism. Similarly, Vertebrate animals can be arranged in a series beginning with mammals and ending with fishes.

Classification by Type : According to Whewell natural classes are obtained by Type. Type is an example of a class which has, in a prominent degree, the leading and important characteristics of the class. All individuals having resemblance with the Type are gathered round it and a class is formed. Water may be taken as a 'Type' to form the class liquid. Stone may be taken as a 'Type' to form the class solid. According to Jevons, a Type is an individual and no other individual can be like it. It may be objected further that selection of a Type is not possible unless we know earlier the important qualities of the class. That is, we must know the connotation of the class or in other words, we must define the class before we select the Type. It may be remarked that popular classification proceeds by 'Type'. We do not popularly bother to find out the connotation while forming a class. We are content with general resemblance and a Type helps us in recognising the members of the class.

Classification by Definition : Mill is of opinion that a Type suggests to which group an individual probably belongs, but it cannot decide whether it really belongs to the group or not. An individual belongs to a group provided it possesses the qualities specified in the definition.

According to Mill, Classification is based on definition. We find out the essential characteristics of the class and select individuals having these characteristics as belonging to the class. Some logicians point out that this method is not without difficulties, since according to this view, idiots and lunatics cannot be included in the class 'man', if it be defined as rational animal. It may be remarked that Whewell speaks of ordinary classification, but Mill speaks of ideal classification.

It may be noted, however, that though Popular classification is based on mere resemblance, Scientific classification should be based on resemblance of essential qualities. So Mill's view is preferred from the standpoint of science.

Use of Classification

Carveth Read enumerates two uses of classification :

(i) Classification helps better understanding of facts. In this respect it is similar to explanation. Points of similarity and difference are noted in classification to put the individuals into classes and these classes into higher classes. Explanation also does the same thing in order to discover the causes or laws of their operation. When a thing is placed scientifically under a class, it is partly explained. When we know that the Zebra is like a horse, it is no longer completely unfamiliar.

(ii) Classification is an aid to memory. To remember a large number of things is pretty difficult. But if they are grouped in classes, it is easy to remember. Retention in mind and recollection become easier when the points of similarity and difference are noted.

Further, Scientific classification contributes largely to the advancement of knowledge. It also helps inference by Analogy, since Analogy depends on important points of similarity.

Limits of Scientific Classification

Scientific classification is based on definition. So the limit of definition is the limit of classification.

(i) Summum Genus or the highest class cannot be classified, because there is no class higher than it.

(ii) Marginal instances cannot be scientifically classified, because they partake of the nature of at least two classes. 'Bat' flies like a bird, but suckles its young ones like a mammal. 'Jelly' is of the nature of both solid and liquid.

(iii) Composite objects cannot easily be classified. Jevons gives the example of granite, which is a combination of three elements in various proportions.

(iv) Taste, smell etc. may be of infinite varieties and they cannot be classified into a limited number of classes.

EXERCISE

1. Explain the nature of Classification and distinguish it from Division.
2. Give a comparative estimate of Natural and Artificial classification. What is the objection to this sort of classification.
3. Distinguish between Classification by Type and Classification by Definition. What is the advantage of Classification by Series ?
4. What are the uses of Classification ? Is it possible to classify scientifically everything ?
5. Classify the following :

   Triangle, table, mango, aeroplane, language, pen, honesty.

12

Vyāpti and Nyāya Inference

Nature of Vyāpti

Vyāpti is the unconditional invariable concomitance between two events, e.g., 'All smoky objects are fiery', 'All men are mortal'. Smoky objects are always found to be fiery. Men are always found to be mortal. No exception is found in the relation between smoke and fire and between men and mortality. So the relation is invariable. Further, the relation is also unconditional, because nothing more is required for smoky objects to be fiery or for men to be mortal. Being smoky is enough to be also fiery, and similarly being human is sufficient for something to be also mortal. So 'All smoky objects are fiery' and 'All men are mortal' are Vyāpti. But 'All fiery objects are smoky' and 'All mortal beings are men' are not Vyāpti, because fiery objects to be smoky, another condition is necessary, i.e., wet fuel; a mortal being to be a man, it is necessary that it must be also rational. So 'All fiery objects are smoky' and 'All mortal beings are men' are not Vyāpti. In fact, these two statements are false.

A Vyāpti relation is always materially true and universal in form. Vyāpti may be either positive or negative. 'All smoky objects are fiery' is an example of positive Vyāpti. It also implies that 'No non-fiery objects are smoky' or 'All non-fiery objects are non-smoky'. Expressed thus, it is an example of negative Vyāpti.

Vyāpti is the relation of pervasion. What pervades is called Vyāpaka. What is pervaded is called Vyāpya. In the above example,

fire is the Vyāpaka and smoke is the Vyāpya. Smoke is always accompanied by fire, but fire may not be accompanied by smoke, e.g., red-hot iron ball.

Vyāpti is a relation of co-existence, but every case of co-existence is not a case of Vyāpti. In many cases, smoke co-exists with or accompanies fire, but still, 'All fiery objects are smoky' is not a case of Vyāpti, since there may be fire without smoke. The relation is neither universal nor unconditional. On the other hand, fire always co-exists with or accompanies smoke. There is no exception. The relation is unconditional. So 'All smoky objects are fiery' is a Vyāpti relation.

A Vyāpti between two terms of equal extension is called Samavyāpti or equipollent concomitance, e.g., All men are rational animals. Here we may infer either of the terms from the other, since both are co-extensive.

A Vyāpti between two terms of unequal extension is called Asamavyāpti or Viṣamavyāpti or non-eqipollent concomitance, e.g., All men are mortal. Here we may infer the Vyāpaka 'mortality' from the Vyāpya 'men' but not *vice versa*.

If we compare the positive and the negative Vyāpti, we find that in positive Vyāpti, Vyāpya is the subject term and Vyāpaka is the predicate term. But in negative Vyāpti, the contradictory of Vyāpaka is the subject term and the Vyāpya or its contradictory is the predicate term.

Importance of Vyāpti in Inference

In Western Logic, a distinction is made between formal or deductive logic and material or inductive logic. Deductive logic deals with formal truth and the conclusion is always less general than the premises. But Inductive logic deals with material truth and the conclusion is always more general than the premises. Induction establishes the material truth of a general real proposition and Deduction amplifies all its implications. So by a combination of both

these forms of inference, we get indirect or inferential knowledge of all sorts.

According to the Indian tradition, the aim of all inferences is to give materially true knowledge. So every valid inference is at once formally valid and materially true. A three-membered valid syllogism of western logic may be formally valid but materially false. But a five-membered valid syllogism of Nyāya Śāstra is both formally valid and materially true. In western logic, the material truth of a general real proposition is established by a distinctive process, i.e., the induction. But in Indian logic, this sort of knowledge or the knowledge of the Vyāpti is not taken as the result of a distinctive form of inference different from the syllogism. Vyāpti is taken as the very basis of syllogism. No inference is possible without it. The Neo-Naiyāyikas have made elaborate discussion on Vyāpti, but they have done so, not treating Vyāpti as a separate process different from syllogism, but treating it as the very ground of syllogistic reasoning. Vyāpti being an essential part of syllogism is defined as the universal and unconditional relation between the 'hetu' or the middle term and the 'sādhya' or the major term.

Besides Vyāpti, Pakṣadharmatā is also necessary for syllogistic reasoning. Pakṣadharmatā is the knowledge of the hetu in the pakṣa. The knowledge of Vyāpti and Pakṣadharmatā leads us to the process called Liṅga Parāmarśa. It is through liṅgaparāmarśa or knowledge of the middle term as universally related to the major and as characterising the minor that the knowledge of the relation between the major and the minor is inferred. So inference is the knowledge arising from Parāmarśa.

In order to determine the role of Vyāpti and Pakṣadharmatā in inference, it is said that Vyāpti is the logical ground and Pakṣadharmatā is the psychological ground of inference. The validity of the inference depends on Vyāpti and its possibility depends on Pakṣadharmatā. Unless the Pakṣa or the minor term be characterised by the Liṅga or the middle term, no inference is possible. But the

inference becomes valid only when the Liṅga is universally and unconditionally related to the Sādhya or the major term.

There is difference of opinion among Indian logicians as to whether Liṅgaparāmarśa or Vyāpti is the proper cause of inference. The Bauddhas, the Jainas and the old Naiyāyikas lay stress on Liṅgaparāmarśa while the Mimāmsakas and the Vedāntins lay stress on Vyāpti on this point. Most of the Neo-Naiyāyikas opine that the utility of Liṅgaparāmarśa depends on Vyāpti. So Vyāpti is the proper cause of inference. But it may be pointed out that the knowledge of Vyāpti by itself does not lead us to the conclusion. It is Liṅgaparāmarśa which fastens together the Pakṣa, the hetu and the Sādhya into one individual whole and it ultimately leads to the relation of the Pakṣa and the Sādhya in the conclusion. So even if it be conceded that Vyāpti is the proper cause of inference, Liṅgaparāmarśa should be recognised to be the immediate cause or carama kāraṇa of the inference.

Methods of ascertaining Vyāpti

Experience can give us knowledge of only particular instances. So we cannot establish the material truth of a general proposition by experience alone. In order to get material truth, experience or empirical knowledge is essential, but howsoever wide our experience may be, it can give us the truth of only a particular proposition. How, then, is the knowledge of the material truth of a general proposition derived ? In other words, how is Vyāpti known ? In western logic this is the problem of Induction.

The Cārvākas do not recognise inference as a source of true knowledge and so have no problem. According to them, certain knowledge is necessarily of limited totality.

The Buddhists base the knowledge of general propositions or Vyāpti on the *a priori* principles of causality and essential identity.

Essential identity is neither complete identity nor the relation of two completely distinct entities. There is identity of essence

between a class and its sub-classes. Similarly, there is essential identity between a class and its members. The relation between *Śimśapā* and tree is such that if a thing is not a tree it cannot be a *Śimśapā*, but if it is a tree it is not necessarily a *Śimśapā* . So it can be said that all *Śimśapās* are trees, but we cannot say that all trees are *Śimśapā*

Two things related by causation are such that the presence of one necessarily implies the presence of the other. So in this case, we can also derive the knowledge of a general proposition. To establish causal relationship the Buddhists adopt the method of Pañcakāraṇī. In order to fulfil the requirements of this method it should be possible to perceive the happening of events as follows :

1. Neither A nor B is perceived.
2. A is perceived.
3. Immediately after this, B is perceived.
4. A disappears.
5. Immediately after this, B disappears.

Then A is said to be causally related to B and the proposition 'All A is B' is asserted to be materially true. This method of the Buddhists is similar to the double application of Mill's Method of Difference.

The Vedāntins' method of ascertaining Vyāpti is similar to that of Induction per simple enumeration. Uncontradicted experience of agreement in presence between two things leads to assert Vyāpti between them. "*Vyabhicārādarśane sati sahacāradarśa nam*".

The Naiyāyikas suppo-t the Vedāntins' method of ascertaining Vyāpti in preference to that of the Buddhists. According to the Naiyāyikas there may be Vyāpti between two events even when there be no causal connection or essential identity between them, e.g., day and night. There is essential identity between tree and *Śimśapā* . but all trees are not *Śimśapā*. The relation established by pañcakāraṇī method is not always causal and where there is pos-

sibility of plurality of causes, the effect cannot be said to be universally related with a particular cause. The Naiyāyikas, therefore, support the method of the Vedāntins, but they supplement uncontradicted experience between two facts by 'tarka' or indirect proof and by sāmānyalakṣaṇa perception.

The following steps for ascertaining Vyāpti as adopted by the Naiyāyikas are worth mentioning :

1. **Anvaya** :—First, we observe that there is uniform relation of agreement in presence or anvaya between two things, e.g., wherever there is smoke, there is fire.

2. **Vyatireka** :—Secondly, we see that there is also a uniform relation of agreement in absence or vyatireka between them, e.g., wherever there is no fire, there is no smoke.

3. **Vyabhicārāgraha** :— Thirdly, if no contrary instance or vyabhicāra is observed in this relation, e.g., there is no case of smoke without fire, then we are led to conclude that there must be a natural relation of invariable concomitance between them.

4. **Upādhinirārsa** :—The Naiyāyikas feel that in spite of the satisfactory fulfilment of the requirements of the above three steps, there is no certainty that the relation is Vyāpti. Vyāpti must be unconditional. So, it is necessary to discover whether the relation is dependent on any condition or not and to eliminate it, if there be any. A condition or upādhi is defined as a term which is coextensive with the major but not with the middle term of an inference. "*Avyāptasādhano yah sādhyasamavyāptirucyate sa upādhiriti*". All smoky objects are fiery, but all fiery objects are not smoky. So for smoke, besides fire something else is necessary. This is found to be wet fuel. Fire with wet fuel invariably and unconditionally is accompanied by smoke. Smoky objects to be fiery, no further condition is necessary. So this is a Vyāpti. But fiery objects to be smoky a condition,i.e., 'wet fuel' is necessary. So it is not a Vyāpti. But fiery objects with wet fuel are unconditionally smoky. So this is also a Vyāpti, because the Upādhi has been eliminated here. The Naiyāyikas recommend repeated observation or bhūyodarśana

under varying circumstances in order to discover upādhi and to eliminate it for the purpose of ascertaining a Vyāpti, which must always be niyata and anaupādhika, i.e., invariable and unconditional.

5. **Tarka** :—The Naiyāyikas would fortify a Vyāpti thus ascertained by 'Tarka' or indirect proof, if any body still doubts it. If Vyāpti like 'All smoky objects are fiery' be supposed as false, then its contradictory proposition 'Some smoky objects are not fiery' must be true. This means that there may be smoke without fire, which is same as asserting that there may be an effect without cause. This is impossible. But if somebody still does not realise his untenable position, the practical contradiction or *Vyāghāta* in his position may be pointed out by questioning him as to why does he need fire to smoke his cigarette ? Thus the contradictory of the Vyāpti being proved to be false, the Vyāpti is recognised as true.

6. **Sāmānyalakṣaṇa perception** :— The Naiyāyikas were conscious that the generalisation from some instances of a class having some quality to all instances of the class having that quality is logically faulty. So, they ultimately used to base Vyāpti on Sāmānyalakṣaṇa perception or perception of the class-essence. Men differ from one another in many respects but they are same in respect of manhood. It is because of this that they are put under the one class 'man'. When a quality is perceived to be connected with the class-essence 'manhood', naturally it is to be found in all men. Ram, Hari, Sita, etc. are mortal not because they are tall or short or handsome, but because they are men. To see the individuals as instances of the class-essence is to have a Sāmānyalakṣaṇa perception. It is only when we perceive manhood as related to mortality that we can say that all men are mortal, because to perceive manhood is to perceive all men so far as they are man-as-such.

Nature of Nyāya Inference and Its Relation with Syllogism

Nyāya Inference or Nyāya Anumāna is at once formally valid and materially true. So the Naiyāyikas recognise it to be a source of true knowledge or a Pramāna. According to the Naiyāyikas, there

are four Pramāṇas. They are Pratyakṣa or perception, Anumāna or inference, Upamāna or comparison and Śabda or testimony. The literal meaning of Anumāna (Anu+māna) is knowledge which follows some other knowledge. In Anumāna, we note that a certain thing has a mark. This mark invariably and unconditionally indicates the presence of some quality. So the thing must possess that quality. It is the process of ascertaining not by direct perception but through the instrumentality or medium of a mark or liṅga that a certain thing possesses a certain characteristic. Knowledge by Anumāna or inference arises only after the knowledge of Vyāpti, pakṣadharmatā and liṅgaParāmarśa. So it is different from perception or direct knowledge.

To see fire on the hill and to know that the hill is fiery is perceptual knowledge. But to see smoke on the hill and since smoke is invariably and unconditionally related to fire, to know that the hill is fiery is inferential knowledge. Finding Devadatta dead, we know that he is mortal; it is perceptual knowledge. But perceiving manhood in Devadatta, if we know that he is mortal, since all men are so, it is inferential knowledge.

The reasoning involved in the Anumāna of Nyāya system and the categorical syllogism of the Western Logic is virtually the same, but the manner of expression differs.

In both the cases, there are three terms, *viz* , Pakṣa or the minor term, Sādhya or the major term and Hetu or the middle term. In both, there are three propositions, *viz.*, Pakṣāvayava or the minor premise, Sādhyāvayava or the major premise and Siddhānta or the conclusion. But while in the syllogism, when expressed in logical form, the order is to state the major premise first, the minor premise next and then the conclusion, in Anumāna, the order is altered.

The Naiyāyikas are of opinion that psychologically the process of inference starts from the recognition of a mark, i.e., the Hetu or the liṅga in something, i.e., the Pakṣa. Then it is remembered that the liṅga has Vyāpti relation with a characteristic, i.e., the Sādhya.

Then a relation is established between the Pakṣa and the Sādhya. So, as a mental process the order of judgements of a syllogism is first Pakṣāvayava, then Sādhyāvayava and lastly the Siddhānta. But when the inference is placed before others in the form of an argument, the Naiyāyikas feel that it should be presented in the form of a five-membered syllogism.

The constituents of the five-membered syllogism are stated in the following order :

1.	Pratijnā	....	Ram is mortal.
2.	Hetu	....	because he is a man.
3.	Udāharaṇa	....	All men are mortal, e.g., Akbar, Alice, Shivaji etc..
4.	Upanaya	....	Ram also is a man.
5.	Nigamana	....	Therefore Ram is mortal.

Pratijnā is the proposition which the speaker proposes to prove. Next he gives the Hetu or the reason for his statement. But the reason advanced can justify the statement only when there is Vyāpti relation between the middle term and the major term. So this Vyāpti relation is exposed in the third proposition with examples. The fourth proposition is the application of the Vyāpti to the present case. And the last proposition is the result of this application. It shows that the proposed statement in the first proposition is finally proved to be true.

The difference in the modes of expression of the three-membered syllogism and the five-membered Nyāya inference is not merely customary. The syllogism is concerned with only formal validity. But the aim of the Nyāya inference is both to render the argument formally valid and the conclusion materially true. So it is considered necessary to make it five-membered. Here the Udāhāraṇa is an attempt to get material truth of a general proposition, which makes the conclusion materially true through the Upanaya. In Western Logic the material truth of general real

propositions is established by Induction. So the Nyāya inference may be said to be at once deductive-inductive.

Classification of Nyāya Inference

The Naiyāyikas classify inference from three standpoints, *viz.*, (i) purpose of inference, (ii) nature of the Vyāpti and (iii) nature of the mode of ascertaining the Vyāpti.

(i) From the standpoint of the purpose which an inference serves, it may be either Svārtha or Parārtha.

Svārtha inference is for the purpose of acquiring knowledge for oneself. It is limited to the mental sphere and proceeds from the perception of the liṅga in the Pakṣa through the memory of the Vyāpti between liṅga and Sādhya to the relation of the Pakṣa and Sādhya. Parārtha inference is for the purpose of demonstrating a known truth to others. It is Pancāvayavī and is expressed in the order of Pratijnā, Hetu, Udāharaṇa, Upanaya and Nigamana.

(ii) From the standpoint of the nature of the Vyāpti the inference may be either Pūrvavat or Śeṣavat or Sāmānyatodṛṣṭa.

In Pūrvavat inference, the Vyāpti depends on causal connection and by perceiving the antecedent cause phenomenon we infer the consequent effect, e.g., we perceive black clouds in the sky and infer that there will be rains.

In Śeṣavat inference also the Vyāpti depends on causal connection and by perceiving the consequent effect phenomenon, we infer the antecedent cause, e.g., we perceive flood in the river and infer that there has been rains in the upper regions of the river.

In Sāmānyatodṛṣṭa inference the Vyāpti is not dependent on causal connection, but on co-existence. So by perceiving the presence of the middle term we infer the presence of the major term, e.g., we perceive that a beast possesses horns and infer that it has divided hoofs.

Some logicians interpret the term Pūrvavat, Śeṣavat and Sāmānyatodṛṣṭa differently. According to them , Pūrvavat in-

ference is that which is based on previous knowledge. So all the three examples cited above are illustrations of Pūrvavat inference. A Seṣavat inference is that which infers a characteristic of something by a process of elimination of other characteristics, e.g., sound must be a quality, because it can neither be a substance nor an action nor a relation. A Sāmānyatodṛṣṭa inference is that in which we do not perceive the relation between the middle term and the major term but find the middle term to be similar to object related to the major term, e.g., The soul substance exists, because consciousness like other qualities must inhere in a substance.

From the standpoint of the mode of ascertaining Vyāpti, inference may be either Kevalānvayi. Kevalavyatireki or Anvayavyatireki.

In Kevalānvayi inference, the Vyāpti is based on only the positive instances of the relation between the middle term and the major term,e.g.,

All knowable objects are nameable.
Pot is knowable.
∴ It is nameable.

In Kevala-vyatireki inference, the Vyāpti is based on only the negative instances of the relation between the middle term and the major term, e.g ,

No non-soul is animate.
All living beings are animate.
∴ All living beings have souls.

In Anvayavyatireki inference, the Vyāpti is based on both the positive and negative instances of the relation between the middle term and the major term, e.g.,

(i) All smoky objects are fiery.
The hill is smoky.
∴ The hill is fiery.

(ii) No non-fiery objects are smoky.
The hill is smoky.
∴ The hill is fiery.

Hetvābhāsa or Fallacies of inference

If in an inference, the term taken as Hetu or middle term is incapable of functioning as a real Hetu or middle term, the reasoning is fallacious and there arises Hetvābhāsa. Hetvābhāsa literally means what appears as but is not really a Hetu.

Hetvābāsa may be of five kinds, *viz* Savyabhicāra, Viruddha, Satpratipakṣa, Asiddha and Bādhita.

The middle term should be invariably accompanied by the major term. Where this is not the case, but still we utilise a term as the middle term, we commit the fallacy of Savyabhicāra or irregular middle, e.g.,

All bipeds are rational.
Swans are biped.
∴ Swans are rational.

If a term, which is accompanied not by the major term but by the contradictory of the major term, be utilised as the middle term, we commit the fallacy of Viruddha, or contradictory middle, e.g.,

Sound is eternal;
because it is created.

It may be noted that the middle term 'created' far from proving the eternality of sound rather proves that it is non-eternal.

If the conclusion established by the help of a middle term can be validly contradicted by the help of another middle term, we commit the fallacy of Satpratipakṣa or inferentially contradicted middle, e.g.,

Sound is eternal ;
because it is audible.

Here the contradictory of the conclusion, i.e., Sound is non-eternal can be proved by the help of another middle term thus :

Sound is non-eternal ;
because it is produced like a pot.

If in an inference, the assumed relation of the middle term in any of the premises is an unproved fact, we commit the fallacy of Asiddha or unproved middle, e.g.,

The sky-lotus is fragrant ;
because it belongs to the class of lotus.

This fallacy is also called Sādhyasama, because here the Hetu or the reason advanced stands as much in need of proof as the Sādhya or what is to be proved.

If the conclusion reached by the help of a middle term is proved to be false by a pramāṇa other than inference, then the inference is said to involve the fallacy of Bādhita or non-inferentially contradicted middle, e.g.,

Sugar is sour ;
because it is a producer of acidity.

The conclusion 'Sugar is sour' is proved to be false by direct perception. So the middle term 'a producer of acidity' is known to be a contradicted middle, realised to be so by perception.

The fallacy of Bādhita differs from the fallacy of Satpratipakṣa since in the former case the conclusion is proved to be false by a non-inferential pramāṇa, but in the latter case the conclusion is proved to be false by another inference.

The fallacy of Viruddha differs from the above two fallacies, since in the above two cases the conclusion is proved to be false by another pramāṇa whether inference or other than inference, but in the case of the fallacy of Viruddha, the middle term itself proves the inferred conclusion to be false.

These three fallacies differ from the remaining two, i.e., the fallacies of Savyabhicāra and Asiddha, since in the former three, the conclusion is proved to be false, but in the latter two, the conclusion remains unproved, i.e., it is neither known to be true nor known to be false. In Savyabhicāra the middle term is known to be irregularly connected with the major term, but in Asiddha the middle term is not known to be connected as asserted.

EXERCISE

1. What is Vyāpti ? Explain with examples different kinds of Vyāpti.
2. What role does Vyāpti play in Nyāya inference ?
3. Give an account of the methods recommended by Indian Logicians for ascertaning. Vyāpti.
4. Give a comparative account of the solutions offered by Indian and Western Logicians on the problem of Induction.
5. Explain the following :
   (a) *Vyabhicārādarsane sati sahacāradars'anam.*
   (b *Avyāptasādhano yah sādhyasamavyāptirucyate sa upadhiriti.*
6. Write short notes on :
   (a) Samavyāpti
   (b) Vyatireki vyāpti
   (c) Liṅgaparāmarśa
   (d) Method of Pañcakāraṇī
   (e) Upādhinirāsa
   (f) Sāmānyalakṣaṇa perception
   (g) Vyāghāta.
7. Describe the nature of Nyāya inference and compare it with syllogism.
8. Give a classification of Nyāya inference and explain each form with examples.
9. What is Hetvābhāsa ? Give a comparative estimate of the different kinds of Hetvābhāsa.
10. Examine the following arguments and name the Hetvābhāsa stating reasons :
    (a) Pārijāta (china rose) is sweet-smelling, because it is a flower.
    (b) Sugar is tasteless, because it is sweet.
    (c) Fire is audible, because it is one of the five elements.
    (d) Gita is apauruṣeya, because it is a scripture like the Vedas.

13

Inductive Fallacies

Some Inductive fallacies have already been noted in the course of the discussion on different topics. We may note here some other important fallacies.

1. Fallacies of Causation

(i) Post hoc ergo propter hoc :

This fallacy literary means—After this, therefore due to this. The cause is an antecedent of the effect, but any and every antecedent is not the cause. If we take any and every antecedent of a phenomenon to be its cause, we commit the fallacy of *post hoc ergo propter hoc*.

This is a source of many superstitions.

A comet appears and a great man dies. The appearance of the comet is supposed to be the cause of the death of the great man. The newly-married bride comes to the house and an old man suffers from fever. The bride is taken as the cause of the old man's fever. One begins work on the 13th of the month and fails to complete it. The cause of the failure is supposed to be the date of the month. In these cases, mere succession is mistaken as causation.

(ii) Fallacy of mistaking a condition to be the cause :

Cause is the sum-total of all conditions positive and negative taken together. We commit this fallacy when we take one condition, whether positive or negative, to be the whole cause.

The boat sinks and a man is drowned. The sinking of the boat is supposed to be the cause of drowning of the man. The other conditions like depth of water, distance from the bank, absence of the knowledge of swimming etc, are ignored. Here we mistake a condition to be the cause.

A seed grows into a tree. The seed is supposed to be the sole cause of the tree. Soil, water, sun-rays, air etc. are ignored. Here we mistake the moving power to be the sole cause.

The dog is absent from the house and the theft occurs. The absence of the dog is supposed to be the cause of the theft. Here we identify a negative condition with the cause.

(iii) Fallacy of ignoring the negative condition :

The effect is produced by the presence of positive conditions and the absence of negative conditions. If the negative conditions be present but not noticed, we fail to account for the non-production of the effect.

High academic qualifications are useless, because in spite of them, the candidate does not get the appointment. Here we are ignoring the negative conditions. Lack of personality, nervousness when interviewed etc. are conditions which must be absent for securing the appointment. If they be present, naturally, the expected result is not produced.

(iv) Fallacy of mistaking a remote cause to be the cause :

The cause is an immediate unconditional antecedent. A remote cause is not unconditional. So a remote cause cannot be taken as the scientific cause.

Success in the battle of Plassey is the cause of the establishment of British rule in India. Defeat in this battle might have created circumstances leading to departure of the British people from India. But this one event does not account for the British rule in India. There are intervening conditions without which British rule would have been impossible in India.

(v) Fallacy of supposing the co-effects of a common cause to be the cause and effect :

When the two co-effects of the same cause are experienced to be occurring successively, the preceding co-effect is supposed to be the cause of the succeeding co-effect.

Fever may be supposed to be the cause of headache, while both may be the co-effects of exposure to cold. Similarly, the falling of mercury in the thermometer is supposed to be the cause of snow-fall, but both are co-effects of the lowering of temperature.

(vi) Fallacy of supposing a part of the cause as a part of the effect :

Heat in summer is supposed to be the cause of perspiration and retardation in work. But retardation in work may be the effect of both heat and perspiration.

(vii) Fallacy of mistaking co-existence as causal relation :

Sweet smell of a fruit may be taken to be the cause of its sweet taste. The scarlet colour of the flower may be supposed to be the cause of its lack of fragrance. In each of these cases, the qualities are co-existent. They are not causally connected.

(viii) Fallacy of supposing the effect to be the cause and the cause to be the effect :

Labour spent on the production of a thing is supposed to be the cause of its value. But value is the cause of spending labour in its production. Laborious dives are supposed to be the cause of the high price of pearls. But the high price of pearls is the cause of laborious diving.

(ix) Fallacy of Non Causa Pro Causa :

The fallacy literally means taking something to be the cause which is not really the cause. All the above eight fallacies may be taken as different forms of the fallacy of *Non Causa Pro Causa.*

It may be mentioned here that this is the modern sense in which the fallacy of *Non Causa Pro Causa* is used. According to Aristotle,

this fallacy "consists in assigning as a reason for some conclusion a proposition which is really irrelevant to that conclusion". Somebody opines : "Death-penalty for murder is just". The opponent argues : "In that case, death-penalty for pick-pocketing is also just, because a penalty is just in so far as it reduces the possibility of the recurrence of the crime. But, surely, it is absurd to award death-penalty for pick-pocketing. So your position is untenable". In this sense *Non Causa Pro Causa* is not an Inductive fallacy. It is not concerned with cause, but with reason. The absurdity in the above case is not the consequent of what was originally asserted.

2. Fallacy of Illicit Generalisation

The fallacy is committed when we generalise wrongly. When a causal connection is established between two phenomena, we can legitimately generalise the relation. Thus the result of Scientific Induction is taken as a correct generalisation. But when we generalise by the help of Induction per simple Enumeration, the generalisation is only probable, the probability depending on the number of positive instances and the lack of negative instances. Sometimes we hastily generalise on the basis of a very few observations in a limited sphere. This leads to the fallacy of hasty generalisation or Illicit generalisation.

A foreign visitor visits a few prosperous cities of a country. From this if he concludes that the country is prosperous, he commits the fallacy of Illicit generalisation. A few Americans visit our home town; they are tall and handsome. From an observation of them if we conclude that all Americans are so, we commit the fallacy of Illicit generalisation. A child in a villlage who has seen only brown dogs concludes that all dogs are brown. It is a case of Illicit generalisation.

3. Petitio Principii

Petitio Principii means "assuming the very point proposed for debate at the outset. " We propose to prove a proposition but

assume it in the course of proving it. Mill commits this fallacy when he tries to prove the law of Uniformity of Nature by Induction per simple Enumeration., for Induction per simple Enumetration reaches its conclusion by assuming the law of Uniformity of Nature itself.

If we say, glass is transparent, because we can see through it or you are a traitor, because you gave out the secret to the enemy, we commit the fallacy of Petitio Principii. Here the premise and the conclusion mean the same thing.

Aristotle illustrates this fallacy in a syllogistic form thus :

Every rectilinear three-sided figure has its angles equal to two right angles.

Every triangle is a rectilinear three-sided figure.

∴ Every traingle has its angles equal to two right angles.

The fallacy of Petitio Principii is also committed when the premise for a conclusion can be proved only by the help of the conclusion.

If we argue that God exists because the scriptures say so, and what the scriptures say must be true because they originate from God, we commit the fallacy of Petitio Principii. In this form it is also called the fallacy of *Circulus in demonstrando* or Arguing in a circle.

Other Examples of Petitio Principii

(i) Ram is a matriculate because all the students of his class are matriculates.

Here to prove that all students of Ram's class are marticulates, we must take Ram along with other students and show that they are matriculates.

(ii) Healing Art is knowledge of what is wholesome.

Healing Art is knowledge of what is unwholesome.

∴ Healing Art is knowledge of what is wholesome and what is unwholesome.

Here the two premises taken together mean the same as the conclusion.

(iii) Ram is the son of Dasaratha.

So Dasaratha is the father of Ram.

Here the same fact leading to the same proposition has been expressed in two different sentences that have been used as the premise and the conclusion.

4. Fallacy of Falsity of Premise

We commit this fallacy when we argue from a premise which is itself false.

He must be suffering from a disease, since he went to the hospital.

Here we have assumed a premise, i. e., All who go to the hospital must be suffering from some disease, which is obviously false.

5. Fallacy of Undue Assumption

We commit this fallacy when we unduly assume a premise. The fallacies of Petitio Principii and Falsity of Premise are considered as different forms of this fallacy. In Petitio Principii, we assume the very conclusion in some form or other, which is not proper. In Falsity of Premise, we assume a premise which is itself false.

6. Fallacy of Ignoratio Elenchi

Ignoratio Elenchi literally means "Ignoring the point in question". An assertion is refuted when its contradictory is proved. We commit this fallacy when we take an assertion to be refuted by proving something not necessarily its conrtadictory. Ignoratio Elenchi in a broad sense means arguing besides the point. We are said to commit this fallacy when instead of the required conclusion a proposition which may be mistaken for it is established".

(i) *Argumentum ad hominem*

By this we direct our arguments to the opponent and not to the point at issue.

A speaker advances arguments in favour of family planning. Without examining the cogency of his argument, if somebody

remarks that the speaker must be talking nonsense because he himself has five children, he commits the fallacy of Argumentum ad hominem.

(ii) *Argumentum ad Populum*

By this we appeal to the passion and prejudice of the audience and not to their reason. The audience are persuaded to accept the conclusion of the speaker rather than given reasons for accepting it.

Examples

(a) Accept the Darwinian theory of evolution if you will, and make your fore-fathers apes.

(b) The youth of today were born in Independent India. They are surely not slaves to worn-out ideas of the past. They brook no dictation from above. Let them think freely. I am confident, they will agree with me that the present system of education needs drastic change.

(c) You do hard work all day long, but what do you own ? Is it enough for a decent living for a man like you ? Are not your dear wife and dearer children ill-fed and semi-naked ? Does your son, able and qualified, on whom you bank so much, get the job he rightly deserves ? I leave it on you to decide whether to permit or not the ruling party to play its nasty trick on you again.

(iii) *Argumentum ad ignorantiam*

By this we establish our conclusion taking advantage of the ignorance of the people. Sometimes we ask the opponent who holds the opposite view to ours to prove his conclusion. If he fails to do so, it is taken as a proof for our own conclusion.

An administrator asked the Statistics Department to supply him some information for his speech which was to be delivered in the evening. The Statistics Department said that they required minimum three months time to supply him all the information he sought. The Administrator, however, delivered his speech and all

the information, which he sought in the morning, was there with minute details. When asked by the Statistics Department as to how could he collect all the information he needed in such a short period, he replied that if the qualified statisticians would take three months to prove him wrong, the lay public will take three years !

One tells one's opponent that he will surely go to hell after his death. If he thinks otherwise, let him prove his position.

(iv) *Argumentum ad verecundiam*

By this an appeal is made to the sentiment of reverence or veneration for authority rather than to reason. We take that something must have been true, because the scriptures say so or some greatmen have said so.

In spite of all that Darwin has said the theory of Special Creation must be true since the Bible says so.

Non-violence is the best code of life because both Lord Buddha and Mahatma Gandhi have said so.

(v) *Argumentum ad baculum*

By this we prove our point to be right by fighting it out. Formerly individuals decided the point at issue by a duel. Now, nations practise it. When the suspect does not confess, the police uses force to prove its own conclusion.

The leader of the terrorist party points a gun at the head of the rich man and asks, 'Don't you agree that we are fighting for a noble cause ?' The answer cannot but be 'Yes'. Then, let us have a lac of rupees as your contribution to this noble cause, he adds.

7. Fallacy on Non-Sequitur

Non-Sequitur literally means "it does not follow". The consequent is affirmed, when the condition is satisfied, i. e., when the antecedent is true. But it does not follow that the antecedent can be affirmed when the consequent is true. This is also called the fallacy of the consequent.

If there is the sun, there is light.
There is light.
∴ There is the sun.

This ignores the possibility of plurality of causes and takes for granted that the consequent and the antecedent are convertible.

8. Fallacy of Plures Interrogationes

Plures Interrogationes literally means many questions.

By this at least two questions are combined and a plain answer—Yes or no is demanded. A lawyer cannot say 'yes' or 'no' if he is asked : Are you not a lawyer and a liar ?

It is not possible to answer yes or no to the question : Are Ram and Sita males ?

Sometimes an assumption is involved in the question which may not be true.

Have you left thieving ?

If you say 'Yes', you were a thief. If you say 'No', you are a thief.

EXERCISE

1. Explain the different kinds of fallacies of Causation with examples.
2. What is meant by Non causa Pro Causa ? Give illustrations of five kinds of Non causa pro causa.
3. Why is Illicit generalisation called hasty generalisation. What are the necessary conditions of a legitimate generalisation ?
4. What is the fallacy of Undue Assumption ? Explain different forms of this fallacy with examples.
5. Write short notes on :
   (a) Fallacy of Non-sequitur
   (b) Fallacy of Plures interrogationes
   (c) Fallacy of Post hoc ergo Propter hoc.
6. Explain clearly the fallacy of Petitio Principii. How is it related to Arguing in a circle ?
7. Explain the different forms of the fallacy of Ignoratio Elenchi.
8. Construct two reasonings to illustrate each of the following fallacies :
   (a) Fallacy of mistaking a negative condition to be the cause
   (b) Fallacy of ignoring a negative condition
   (c) Fallacy of supposing the effect to be the cause and the cause to be the effect.
   (d) Fallacy of using persuasion in place of reasoning
   (e) Fallacy of giving wrong information taking advantage of the ignorance of the opponent
   (f) Fallacy of proving a statement by expressing the same statement in a different form of language.
9. Test the validity of the following arguments :
   (a) Immediately after the falling down of the crest flag of the Jagannath Temple, cyclone, flood and out-break of epidemic diseases took place in Orissa. So the former event is the cause of the latter disasters.
   (b) Lemon-water tastes fine when a spoonful of sugar is added. So sugar is the cause of the fine taste.
   (c) There are cases of theft in this locality because there is no police-station near about.
   (d) What is the good of educating children when even educated people are unemployed ?

(e) The death of the father led to the divison of the paternal property. The unemployed youngest brother became poorer day by day, his share of property being insufficient to make both ends meet. Taking of non-nutritious food led to his colic pain. So the death of his father is surely the cause of his colic pain.

(f) Learning gives humility, humility leads to status. From status we get wealth. By wealth we acquire virtues and thereafter get happiness. So learning is the cause of happiness.

(g) The high temperature of the malarial patient is the cause of his feeling cold.

(h) Flame is the cause of light.

(i) The people of Japan are industrious, for the cottage industry in that country is highly developed.

(j) Lack of intelligence is the cause of his laziness and poverty.

(k) This year, in all M.A. Examinations of the University the lady students have secured the first positions. So the lady-students of this University are more intelligent than the gent-students.

(l) He has crossed the age 18. Therefore he is major.

(m) Sita is the wife of Ram, because Ram is the husband of Sita.

(n) This girl must have been married. See, she has a vermilion mark on her forehead.

(o) I have seen the speaker drinking. So his arguments in support of prohibition cannot be justified.

(p) What ! your own son, on whom you spent such a lot in bringing him up in a decent way and giving him the best education, dares to challenge the cogency of your argument ? Certainly, he cannot be logically correct.

(q) Eating, drinking and being merry is justified even if this requires incurring loans, since great hedonists prescribe such a course of life.

(r) King Kansa suffered from malaria thrice. If you challenge the veracity of this statement, prove it to be false.

(s) Bind the hands and legs of your son together with a rope, give him neither food nor water and throw him in a dark room. He will understand you to be right in no time.

(t) When the mother dies, the children cry. The children of this house are crying; so their mother must have been dead.

(u) No dilly-dallying please; answer yes or no; have you left your drinking habits ?

(v) When I started studying, my neighbour switched on the radio. He must be a malicious man.

(w) This patent medicine must be good, since many men of position testify to its efficacy.

(x) One of the sailors rescued wore an amulet. Surely this is the cause of his escape.

(y) This man is a coward, because he does not dare perform an act of bravery.

(z) During my last visit to New Delhi, one whole morning I devoted to meet some M.Ps at their residence, but none was present. So I concluded that All M . Ps must have gone out of the Capital that day.

10. Comment on the fallacies involved in the following. (These fallacies are not limited to the subject-matter of Chapter 13

(a) Every State like a living organism has origination, growth and destruction. A small state like a pigmy has, therefore,to face many hurdles.

(b) Heat expands bodies. So heat is the only cause of expansion.

(c) We see that the sun rises and sets. So the sun revolves round the earth.

(d) The new teacher must have been a very wise man, because none in the class really understands his lecture.

(e) Charles I was a great lover of his wife and a critic of painting. So the English people were not justified in revolting against him.

(f) None of the people I have come across is unselfish. So every man is selfish.

(g) I find that the book kept on the rack this morning has disappeared. It must have been the work of some ghost.

(h) After independence, we find that as time passes on, dishonesty is increasing day by day. So getting independence is the cause of dishonesty.

(i) My father says that the climate of Bhubaneswar is unhealthy. So it must be so.

(j) Hitler's attack of Russia is the cause of his downfall.

(k) Great intellectuals always have a short span of life. This is proved from the early deaths of Sankar, Shelly, Keats and Vivekānanda.

(l) Nothing can come out of nothing. So some invisible power is the Creator of the universe.

(m) No risk, no gain. You have gained nothing. So you did not risk anything.

(n) Increase in the strength of Colleges is the cause of Students' unrest.

(o) This man is as wise as he is amiable. So wisdom is the cause of amiability.

(p) Who says that steel does not dissolve in water ? One rainy night, my steel knife accidentally fell through the window on the street below. Next morning, there was no trace of it.

(q) The Temple increases and decreases. It goes on decreasing as you see it, going farther and farther. It goes on increasing as you approach it nearer and nearer.

(r) I like all the songs sung by Lata Mangeskar, but I do not like the same tunes when played on the musical instruments only. So accompaniment of instrumental music adds no charm to the song.

(s) He must be a postal employee. I have seen him going to the Post Office very often.

(t) The Magician shows wonderful tricks every time by waving his wand. So the waving of his wand is the cause of the wonderful results.

(u) A child is like soft clay. You can mould it as you please.

(v) Sanskrit literature is useless, since the modern men take no interest in it.

(w) The future will resemble the past, for Nature behaves uniformly.

(x) Machine works well if the operator knows his business well. So also students would read and behave well if teachers know their business well.

(y) You preach only when you fail to practise.

(z) He is an atheist because he does not believe in God.

C.H.S.E. QUESTIONS

2000 – Annual

Paper – II

Group – A

Answer **all** questions :

1. (a) What is inductive leap ?
   (b) What is the qualitative mark of a cause ?
   (c) Define unscientific induction.
   (d) What are the material grounds of induction ?
   (e) State the doctrine of plurality of causes.
   (f) What is meant by hypothesis ?
   (g) Which methods of Mill are methods of discovery ?
   (h) What is observation ?
   (i) Is method of residues a method of experiment ?
   (j) Give an example of fallacy of ambiguous minor.
2. Fill in the blanks :
   (a) — and — are the formal grounds of induction.
   (b) In — intermixture of effects, the separate effects and the joint effect are of different type.
   (c) The conclusion of unscientific induction is —.
   (d) When a hypothesis is verified, it becomes a —.
   (e) Observation is natural, but experiment is —.
   (f) The method of concomitant variation is applicable in cases of — causes only.
   (g) Fallacy of — arises due to misplaced accent or emphasis on different words in a sentence.
   (h) When we appeal to the passion and prejudice of audience and not to the reason, we commit fallacy of —.
   (i) Method of agreement is better said to be a method of — rather than method of proof.
   (j) The method of — is said to be a modification of the method of difference.

Group – B

3. Answer any **ten** of the following questions :
   (a) Discuss what is primary induction.

(b) Name the different steps of inductive procedure.

(c) What is induction by parity of reasoning ?

(d) What is bad analogy ? Give example.

(e) Explain what is meant by paradox of induction.

(f) What do you mean by hypothesis concerning law ?

(g) Distinguish between positive and negative conditions.

(h) What is meant by fallacy of non-observation ?

(i) Briefly explain one of the disadvantages of Mill's method of difference.

(j) Distinguish between intermixture of effects and conjunction of causes.

(k) Explain the characteristic imperfection of Mill's method of agreement.

(l) What is fallacy of division ?

(m) Explain, with example, the fallacy of mistaking a condition to be a cause.

(n) What do you mean by fallacy of argumentum ad hominem ?

Group – C

Answer any **four** questions :

4. Explain the characteristics of unscientific induction.
5. Discuss the advantages of observation over experiment.
6. State and explain the method of concomitant variation.
7. Explain what constitutes the proof of a hypothesis.
8. How will you determine the strength of analogical argument ? Discuss.
9. Distinguish between :

   (a) Cause and Condition

   (b) Agent and Patient.

10. Test the following arguments :

   (a) Every politician is either intelligent or rich.

   This politician is rich.

   ∴ He is not intelligent.

   (b) Observing some foreigners healthy, strong and capable we judge that all citizens of that country are so.

   (c) If he is intelligent, he will pass in the examination.

   He passes in the examination.

   ∴ He is intelligent.

1999 (A) Paper – II

(As per 1999 Syllabus)

Group – A

Answer **all** questions :

1. (a) Name the different kinds of induction proper.
   (b) Define colligation of facts.
   (c) What are the two material grounds of induction ?
   (d) What are the quantitative marks of a cause ?
   (e) What is paradox of induction ?
   (f) What is meant by hypothesis ?
   (g) Which methods of Mill are methods of proof ?
   (h) State one of the advantages of experiment over observation.
   (i) Which methods of Mill are methods of experiment ?
   (j) Give an example of fallacy of ambiguous major.
2. Fill in the blanks :
   (a) Induction establishes a general — proposition.
   (b) Unscientific induction is said to be induction per — enumeration.
   (c) Uniformity of nature is a — ground of induction.
   (d) Cause is the — unconditional, immediate antecedent of the effect.
   (e) Hypothesis is a — supposition.
   (f) In observation we proceed from cause to effect or from effect to cause, but in experiment we proceed from — to —.
   (g) The method of agreement fails to distinguish cause from —.
   (h) The method of residues is essentially a method of —.
   (i) In an argument when we proceed from the distributive use of a term to its collective use, fallacy of — arises.
   (j) When the conclusion is assumed in the premises, there arises the fallacy of —.

Group – B

3. Answer any **ten** of the following questions :
   (a) Discuss what is the problem of induction.
   (b) What is perfect induction ?
   (c) Give an example of induction per simple enumeration.

(d) What is the main point of distinction between scientific and unscientific induction ?

(e) What is good analogy ? Give an example.

(f) Name and explain the fallacy committed by paradox of induction.

(g) Distinguish between cause and condition.

(h) What is hypothesis concerning agent ? Give example.

(i) What is crucial instance ?

(j) Make a brief distinction between observation and experiment.

(k) State the canon of elimination on which Mill's method of agreement is based.

(l) Discuss how the method of agreement is frustrated by the doctrine of plurality of causes.

(m) What is the fallacy of affirming the consequent ?

(n) Explain the fallacy of *argumentum ad verecundiam*.

Group – C

Answer any **four** questions :

4. Explain induction by parity of reasoning. Is it an induction proper ? Discuss.
5. Explain with examples the different steps of inductive procedure.
6. 'Observation and experiment differ in degree, but not in kind.' Discuss.
7. Distinguish between :
   (a) Moving power and Collocation
   (b) Plurality of causes and Conjunction of causes.
8. Explain the conditions of a valid hypothesis.
9. State and explain the method of difference.
10. Test the following arguments :
    (a) Observing some foreigners healthy, strong and capable, we judge that all citizens of that country are so.
    (b) Day is the cause of night.
    (c) If he is intelligent, he will pass the examination.
    He passes the examination.
    ∴ He is intelligent.

C.H.S.E. QUESTIONS

1998 – Annual

Paper – II

Group – A

Answer all questions :

1 . (a) State the problem of induction.
(b) State the law of Uniformity of nature.
(c) Define scientific induction.
(d) Name the inductions improperly so called.
(e) Give an example of conjunction of causes.
(f) Mention any one method of proving a hypothesis.
(g) Which methods of Mill are methods of discovery ?
(h) What is experiment ?
(i) Is the method of difference a method of Observation ?
(j) Give an example of fallacy of post-hoc-ergopropter-hoc ?

2. Fill in the blanks :
(a) Law of causation is a – ground of induction.
(b) Doctrine of – states that the same effect may be produced by different causes on different occasions.
(c) The conclusion of scientific induction is –.
(d) Parity of reasoning is – induction.
(e) When facts or particulars which ought to have been observed are neglected, fallacy of – arises.
(f) In joint method we are unable to distinguish causation from –.
(g) Fallacy of – arises in the following argument.
Water is liquid, Ice is water, ∴ Ice is liquid.
(h) When we establish our conclusion taking advantage of the ignorance of the opponent, we commit fallacy of –.
(i) "Mars like the earth has also living beings." This is a – analogy.
(j) Mill's – method requires only two instances.

Group – B

3. Answer any ten of the following questions :
(a) State the reasons for making a transition from deduction to induction.
(b) Explain inductive leap.
(c) What is unscientific induction ? Give example.

(d) Distinguish between analogy and scientific induction.
(e) Explain what is meant by intermixture of effects.
(f) What do you mean by hypothesis concerning collocation ?
(g) Explain what is cause from the stand point of law of conservation of energy.
(h) "Observation is passive, but experiment is active." – Explain.
(i) Discuss how the method of agreement is frustrated by doctrine of plurality of causes.
(j) Distinguish between conjunction of causes and doctrine of plurality of causes.
(k) State the canon of elimination on which Mill's method of concomitant variation is based.
(l) Explain the fallacy of accident.
(m) Explain with example, the fallacy of ignoring the negative condition.
(n) What do you mean by fallacy of argumentum ad ignoration ?

Group – C

Answer any **four** questions :

4. "Induction and deduction differ in their starting point and procedure, but in principle they are same." – Explain.
5. What is observation ? Explain its nature.
6. Why is the method of residues called a deductive method ? Compare it with the method of difference.
7. Explain with suitable examples :
   (a) Experimentum crucis.
   (b) Consilience of induction.
8. How will you determine the strength of unscientific induction ?
9. Discuss Aristotle's view of causation.
10. Test the following arguments :
    (a) Orissa is included in India; India is included in Asia;
    ∴ Orissa is included in Asia.
    (b) The bride came into the house and there after the father-in-law died, hence the bride's coming into the house is the cause of father-in-law's death.
    (c) The climate of Bhubaneswar is unhealthy since the teacher says so.

1997 (A) Paper–II
(As per 1997 Syllabus)

Group–A

Answer all questions

1. (a) Name the different steps of inductive procedure.
   (b) What is perfect induction ?
   (c) Name the two types of condition.
   (d) Name the two types of inter-mixture of effect.
   (e) Mention any one condition of a valid hypothesis.
   (f) State one of the advantages of observation over experiment.
   (g) Which methods of Mill are methods of experiment ?
   (h) Is the joint method a method of proof ?
   (i) What is the fallacy of petitio principle ?
   (j) Give an example of the fallacy of ambiguous minor.
2. Fill in the blanks:
   (a) Induction establishes a —— proposition.
   (b) —— and —— are the material grounds of induction.
   (c) Cause is the ——, unconditional and immediate antecedent of the effect.
   (d) From the stand point of law of conservation of energy the cause is analysed into two parts i.e. moving power and ——.
   (e) Verification of hypothesis is of two types, i.e. —— and ——.
   (f) In observation we proceed from cause to effect or from effect to cause, but in experiment, we proceed only from —— to ——.
   (g) In the method of agreement, we are unable to distinguish cause from ——.
   (h) The Method of Residues is essentially a method of ——.

(i) In an argument when we proceed from the distributive use of a term to its collective use, fallacy of —— arises.

(j) According to ——, the ground of induction is itself an instance of induction.

Group–B

3. Answer any ten of the following questions

   (a) Distinguish between deduction and induction.

   (b) Explain one of the steps of inductive procedure.

   (c) What do you mean by colligation of facts ? Is it an induction proper ?

   (d) What is bad analogy ? Give example.

   (e) Explain the paradox of induction.

   (f) Explain what is cause from the quantitative aspect.

   (g) What is hypothesis concerning agent ? Give an example.

   (h) Explain one of the conditions of valid hypothesis.

   (i) Make a brief distinction between observation and experiment.

   (j) State the canon of elimination on which Mill's method of agreement is based.

   (k) Discuss why the method of difference is not free from the difficulties arising out of plurality of causes.

   (l) Why is the method of residues regarded as a special modification of the method of difference ?

   (m) Explain with example the fallacy of argumentum ad veracundiam.

   (n) What is the fallacy of amphibology ? Give example.

Group–C

Answer any four questions

4. What is experiment ? Discuss the relation of experiment with observation.
5. State and explain the method of Agreement.
6. Explain with examples the different steps of inductive

7. State and explain the conditions of a legitimate hypothesis.
8. Explain and examine the doctrine of plurality of causes.
9. Distinguish between :
   (a) Potential energy and Kinetic energy.
   (b) Cause and Condition
10. Test the following arguments:
   (a) Ram is the son of Dasaratha, Laba is the son of Ram

∴ Laba is the son of Dasaratha.

   (b) Lemon water tastes good when a spoonful of sugar is added. So, sugar is the cause of the good taste.
   (c) A foreign visitor visits a few prosperous cities of a country. From this he concludes that the country is prosperous.

1997 (A) Paper–II
(As per 1996 Syllabus)

Group–A

Answer all questions

1. (a)State the law of identity.
   (b) Name the valid moods of Figure I.
   (c) Give the symbolic representation of BRAMANTIP.
   (d) State any one of the special syllogistic rules of figure IV.
   (e) What is figure of a syllogism ?
   (f) Name the material grounds of induction.
   (g) What is mal-observation ?
   (h) State the principle of elimination of the Method of Difference.
   (i) What is the fallacy of argumentum ad populum ?
   (j) Is the Method of Difference a method of proof ?
2. Fill in the blanks
   (a) There are —— propositions in a syllogism.

(b) BOCARDO is a valid mood of the —— figure.

(c) The —— figure of syllogism is called the perfect figure.

(d) If the middle term is not distributed in any of the premises then it is the fallacy of ——.

(e) In a simple dilemma, the conclusion is always a —— proposition.

(f) Regulated perception is called ——.

(g) The Method of Residues is a modification of ——.

(h) The Method of —— cannot be applied in the case of qualitative variation.

(i) When a rope is mistaken as a snake, the fallacy is ——.

(j) The Method of Concomitant variation is called a —— method.

Group–B

3. Answer any ten questions

(a) Distinguish between inference and argument.

(b) What is the principle of excluded middle ?

(c) What is alternative-categorical syllogism ?

(d) Explain the fallacy of denying the antecedent.

(e) Explain briefly Aristotle's dictum de omni et nullo.

(f) State the special syllogistic rules of Figure III.

(g) What is meant by a fundamental mood ?

(h) What is meant by rebuttal of dilemma ?

(i) Give an example of simple constructive dilemma.

(j) Difine experiment.

(k) Give a concrete example of the Method of Difference.

(l) What is argumentum ad populum ?

(m) What is the fallacy of Paronymous terms ?

(n) Why is the Method of Residu called a method of discovery ?

Group–C

Answer any four qustions

4. Explain the difference between truth and validity. How is logic concerned with them ?
 (a) No conclusion follows from two negative premises.
 (b) If the major premise is particular and the minor negative, no conclusion follows.
6. Reduce CAMESTRES both directly and indirectly.
7. What is observation ? Explain its advantage over experiment.
8. State and explain the Joint Method.
9. State and explain the Method of Agreement.
10. Write nots on .
 (a) Fallacy of amphibology
 (b) Fallacy of accident

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